THE PRINCIPLES OF ORTHOPEDIC SURGERY FOR NURSES

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THE PRINCIPLES OF ORTHOPEDIC SURGERY FOR NURSES

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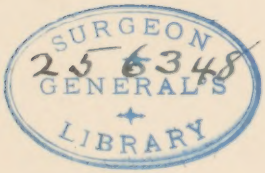

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To

DR. EDWARD HICKLING BRADFORD

EMERITUS PROFESSOR OF ORTHOPEDIC SURGERY
HARVARD MEDICAL SCHOOL
IN GRATEFUL RECOGNITION FOR MANY THINGS

PREFACE

The material in this book is the result of many lectures to nurses on orthopedic surgery. It has been found that lectures alone will not fill the need for more detailed and visual knowledge. Most nurses never have adequate training in the care of orthopedic cases, as such cases generally make up but a small part of the work in a general hospital. It has seemed necessary, therefore, to the author that adequate and primary knowledge of orthopedic surgery and its essentials of nursing technique should be supplied, so that all training schools should be able to provide, at least through a text book, satisfactory and fundamental knowledge of orthopedic surgery to their pupils. It is in no sense intended to be a medical text book, but is intended to supply the nurses with a knowledge of what orthopedic surgery comprehends, and the most accepted methods of treatment. The material is largely drawn from the Children's Hospital, Boston, and the nursing technique is the result of many years' experience in its wards.

I am under the greatest obligation to Miss Ida C. Smith, Superintendent of the Children's Hospital, for valuable aid and coöperation in obtaining material for this book; also to Miss Wakefield, Superintendent of Nurses, and her assistants, Miss Gilman and Miss Tabor, for their assistance in reading and suggestions in regard to the manuscript.

INTRODUCTION

Orthopedic Surgery has been described and accepted by the American Orthopedic Association as the surgery of deformities and disabilities of the apparatus of locomotion. This broad field includes deformities and disabilities of the trunk as well as those of the arms and legs. They may be divided roughly into those which are congenital in origin, and those which have been acquired by accident or disease. In this book, the congenital defects will be presented first as the natural order suggests.

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THE PRINCIPLES OF ORTHOPEDIC SURGERY FOR NURSES

CHAPTER I

CONGENITAL DEFORMITIES

Club feet, congenital dislocation of the hip, torticollis or wry neck, spina bifida occulta, defective development, congenital constriction bands, congenital radio-ulnar synostosis, congenital elevation of the scapula.

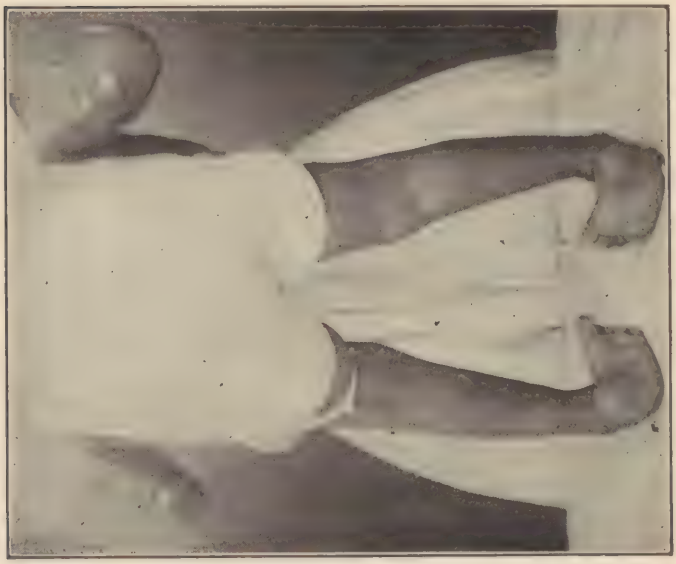
Club Feet or Congenital Talipes Equino-Varus.—This is a deformity of one or both feet due to abnormal compression in the uterus, or to arrested development of the foot. It is often hereditary. The deformity is a dislocation inward, at the medio-tarsal articulation, of the anterior portion of the foot, the sole of the foot being turned in so that the child walks on the outer edge or even on the top of the foot. A large callous or bursa may develop on the outer edge from pressure. The heel cord and the muscles in the sole of the foot are generally much contracted.

A club foot is easily recognized at birth, and no time should be lost in starting treatment. Some young babies hold the feet turned in so that the position resembles that seen in a club foot, but manipulation by the hands will at once differentiate the two conditions. A normal foot can be easily placed in a normal position by gentle force; a congenital club foot cannot be even corrected, or over corrected, by force.

Without treatment, the condition tends to become worse, that is, the deformity becomes more fixed and harder to correct by manipulation or even operative means, and if the individual grows up with such a foot, walking is difficult, and the leg smaller and shorter.

Treatment.—The general outline of the treatment to be employed is as follows:

The foot should be gradually corrected, and then over corrected, and held so for at least a year by adhesive straps, braces or plaster casts, until there is no longer any tendency for the foot when released from fixation, or in weight bearing, to return



No. 2.—Double Congenital Club Foot from Rear.

No. 1.—Double Congenital Club Foot.

to its former position of deformity. This result may be accomplished by the following methods:

First: by retention by adhesive plaster. In milder cases where adequate supervision can be obtained, strips of sticking plaster can be used to correct the deformity. A narrow strip of plaster is carried around the forefoot from the inside out and up the outside of the leg over the top of the knee, well above the end of the thigh, the knee being flexed to a right angle while this sticking plaster is being applied. Sufficient tension should be made on the band of sticking plaster so that the foot is held in a position of correction all the time. That is, the foot should be as much abducted, everted and dorsally flexed as possible. Care should be taken to prevent the edges of the sticking plaster from cutting into the baby's skin. The plaster should be changed at least once a week. The mother or nurse should have instructions to watch the circulation of the toes and watch the skin so that the sticking plaster does not make sores, and at least twice a day the foot should be manipulated by hand in the direction of abduction, eversion and dorsal flexion. At the end of a week, sufficient correction will probably have been gained to warrant the application of a new plaster. This method is applicable as a rule only in milder cases. It has the advantage of being easily done, and is a method where the circulation and the skin can be easily taken care of.

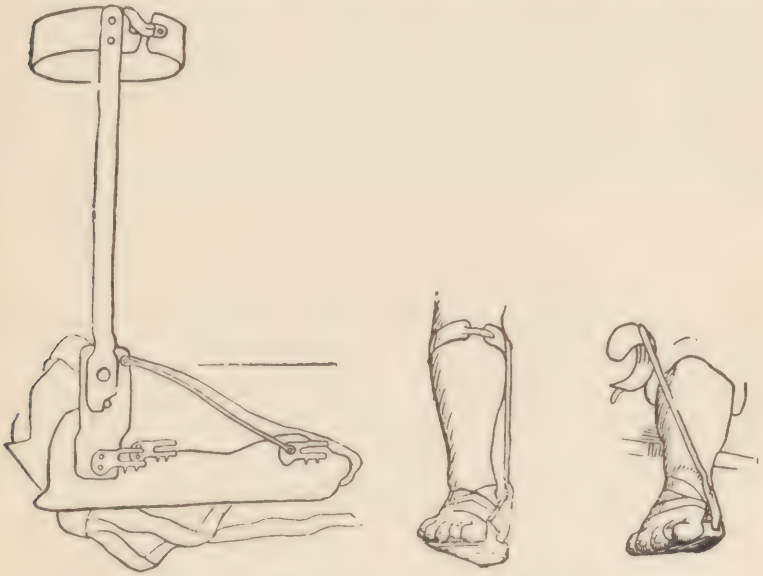
Second: correction by plaster casts in the more resistant types of cases where there is evidently a good deal of resistance to any attempt of correction. The plaster cast should be applied in the following manner: the baby's skin is bathed with alcohol and carefully powdered with talcum powder. The foot from the ends of the toes to well above the knee should be snugly wrapped in sheet wadding not more than 1½ inches to 2 inches in width. Care should be taken to prevent uneven edges or folds in the sheet wadding from making pressure on the skin. Over this sheet wadding, plaster bandages should be applied, the bandages being usually not more than 1 inch to 1½ inches in width, as by using this width, creases in the plaster can be avoided. It is better to apply the plaster first around the front

of the foot, and allow it to harden so as to make a plaster cuff. After this cuff has hardened, the rest of the plaster can then be applied. The foot should be held in as much correction or over correction as possible during the application of the plaster. The plaster should be carried from well below the toes on the sole of the foot to mid thigh with the knee flexed at a right angle. As the plaster is setting, the foot should be held in as much correction as is possible to obtain, taking care to avoid holding the plaster with the ends of the fingers to prevent the formation of dents and pressure spots. Care should also be taken that the plaster is not too tight underneath the knee or in the bend of the ankle where, if it is too tight, it will either make pressure sloughs or interfere with the circulation. The cast should be bivalved, that is, should be cut through on both sides at once as soon as it hardens, and the circulation should be satisfactory in the toes before the child is allowed to go from under observation. The mother should be instructed that if there is any swelling or discoloration of the toes at any time, she is to report immediately to her physician for correction of such condition. If this caution is not given, sometimes serious interference with the circulation occurs, and toes have been known to slough off from undue pressure. If there is any interference with the circulation, the front of the cast should be lifted off, and the sheet wadding split, particularly in the bend of the ankle.

At first, in the resistant type of club foot, all that can be done is to correct the varus or turning in of the forefoot. After this is corrected, then, as a result of a softening up of the contracted muscles and ligaments, the heel cord can be gradually stretched by frequent application of other plasters. These plasters should be changed as frequently as every two weeks, and in the moderate cases at the end of six months, a very good foot will be secured. In the more resistant type of cases, the condition sometimes persists, and more plasters have to be applied, gaining each time, so that eventually the foot is well over corrected, that is, held in a position of abduction, eversion and dorsal flexion.

The essentials to a complete success are that the foot should

stay in a position of correction following the removal of any fixation apparatus, and should also stay in a position of over correction in weight bearing. It takes time to correct the bony deformity which is present in cases of congenital club foot, and only by long persistent and careful effort can such results be accomplished. Following the removal of the plaster,



Retention Appliance, Unapplied and Applied.

(From Bradford and Lovett.—"Orthopedic Surgery")

No. 3.—Varus Shoe for Club Foot. Note in applying club foot shoe that the foot plate is strapped to the foot first, with the upright across the leg. After the foot plate is fitted to the foot, the upright is then swung back to the inner side of the leg, abducting and everting the foot in so doing.

it is generally wise to apply a club foot brace to the foot which can be taken off for bathing purposes. This brace should be worn night and day for a period of six months or a year in order to insure that there is no relapse. During the after care of a club foot, that is, after the plaster has been removed and after the brace has been given up, it may be necessary in some cases to raise the outer side of the sole and heel of the shoe so as to tip the foot in to prevent any tendency of recurrence.

Occasionally in the more severe type of club foot which can-

not be corrected by means of frequent application of plasters or by any other methods, operations have to be done consisting either of a simple tenotomy of the tendo Achillis or a more elaborate operation which divides various ligaments about the foot. These operations, however, are generally reserved for the older and more resistant type of cases, and if the foot has been properly treated from the start, they are generally not indicated.

The definition of talipes equino-varus is as follows: talipes equinus means a dropping downward of the forefoot, the name having been taken from the resemblance to the shape of a horse's foot. Varus is turning in of the forefoot at the medio-tarsal joint with or without inversion of the sole. Talipes equino-valgus is a dropping downward of the forefoot with a turning out of the forefoot at the mediotarsal joint.

Other foot deformities will be considered under the head of infantile paralysis.

Congenital Dislocation of the Hip.—Congenital dislocation of the hip is a fairly common deformity which exists at birth, and is much more common in girls than in boys. It may be single or double. The deformity or condition usually is not recognized at birth, but is generally recognized only when the child begins to walk. It may exist also in connection with other congenital deformities such as club feet or congenital defects of the spine, and especially with a condition known as spina bifida occulta, about which more will be described later. Up to only fairly recent times, it was a condition for which nothing could be done, but in the last twenty-five or thirty years, great progress has been made in the treatment of this condition, particularly by the so-called bloodless operation, which is a manipulative reduction of the hip. In small children, the hips as a rule can be fairly easily reduced. After four or five years, and from then on, reduction becomes increasingly difficult, and after seven or eight or ten years, oftentimes reduction is impossible. Even after reduction has been accomplished at this late age, the resulting functional use of the hip is often very much restricted.

The symptoms of congenital dislocation of the hip are as follows: the leg on the side of the dislocation, if single, is shorter

Nos. 4, 5, 6.—Case of Double Congenital Dislocation of Hips, Front, Side, and Back Views. Note tipping of pelvis, wide perineum, hollow back and prominence of trochanters of hip from behind.

than the other leg, because the head of the femur not being in the acetabulum or socket, slides up along the side of the ilium, and is simply held by muscles and ligaments when weight is put on the leg. As the child gets older, the limp becomes more and more marked, and the leg shorter. If the dislocation, however, is a double one, the limp is not as characteristic as that seen in those cases with only single dislocations. The gait is a sort of waddle with the body of the individual swaying from side to side as he walks. There is also associated with these cases of double congenital dislocation of the hip a good deal of lordosis or hollow back, and a very much increased width of the perineum. One of the tragedies of congenital dislocation of the hip is that it is not recognized early, and often is not recognized until the child is three or four years of age. Such children oftentimes have been treated for hollow backs and poor postures alone and given exercises. They have also been treated for rickets and various other conditions without the actual diagnosis of congenital hip having been made. It is essential that x-rays should be taken of every case that has a limp referred to the hip joint. X-rays will show without question whether or not the hip is dislocated. The treatment, like all other cases that have congenital deformities, should be begun early, provided diagnosis is made early. If diagnosis of this condition is made before the child begins to walk, it is better to operate on the hip at that time, and reduce the dislocation for the reason that, first of all, the dislocation can be much more easily reduced at this stage, than after walking and weight bearing has been carried out for any length of time, and also because there will have been fewer changes take place in the shape of the acetabulum, and in the shape of the head and neck of the femur.

The reason in the past that has prevented early operations in young children, is that the use of plaster of Paris casts have not been conducive to cleanliness, and require a great deal of care in nursing, as they become wet and dirty, and the children are apt to develop bad sores under the plaster. At present, however, we have a metal splint known as the Woo splint which can be applied easily to any child, and which obviates the necessity of waiting until the child has reached the age

No. 7.—X-ray of Case of Double Congenital Dislocation of Hip. Note that neither femur is in acetabulum, but is well above normal acetabulum on each side

where it can control the bladder and rectum. The splint is measured for and fitted before the operation, and is put on immediately after reduction of the hip while the child is still under ether. In most cases, this method of early operation can be easily used, and assures a more satisfactory end result at an early age. If the child has reached the age of eight or ten years, reduction is very much more difficult, if not impossible, and in certain instances it has been advisable to cut

No. 8.—Wood Splint for Case of Congenital Dislocation of Hip After Operation. This splint is for the left leg, with the pelvic horn hinged so that the child can be dropped into saddle of splint easily.

down by open operation on the hip joint, and reduce the hip by this method. This operation is a serious and difficult one, and although it has been done in certain cases, it does not insure as satisfactory a result as those cases which have been reduced by a closed or manipulative method.

The after treatment is very important. After the hip has been reduced by manipulation, it should be held in a splint or plaster cast with the legs in the frog position, that is, widely spread, and the thighs at a right angle to the long axis of the trunk for a period of not less than six months, depending upon

the age of the child and the ease of reduction. The plaster cast goes from the level of the lower ribs to the knee or mid-thigh on the well side, and down to and including the toes on the side which has been reduced. After three months in some instances, and six in others, the front of the cast is cut off or bi-valved, and the cast is completely cut away above the knee on the affected side, and wholly removed from the well leg. The child is then given massage and allowed to kick the leg about in the posterior half of the cast. This treatment is carried out for a period of six weeks to two months so that by the end of eight or nine months the muscles are in good condi-

No. 9.—Child in Bed on Elevated Frame in Plaster Cast Following Reduction of Congenital Dislocation of Hip.

tion, and the leg can be removed from the cast entirely, and the child allowed to walk. This does not mean that the child at that time will walk naturally, or that there will be free motion in the hip. The patient will need a considerable period of physiotherapy, that is, massage, baking and exercises for several months or even a year before the hip is in normal condition. A certain percentage of all cases tend to relapse, that is, redislocate, and the procedure has to be carried out again as outlined.

Torticollis or Wry Neck.—In congenital torticollis, the child is born with the head tipped to one side and with the chin rotated in the opposite direction. This position is due to the contraction of the sterno-cleido-mastoid muscle. The reason the

head is tipped and rotated is because of the fact that the above muscle is contracted, and so shortens the distance on that side of the neck between the mastoid process and the sterno-clavicular notch. The rotation of the head is due to the fact that the muscle runs in an oblique direction from its origin, at the junction of the sternum and clavicle to its insertion on the mastoid process back of the ear. Therefore shortening of this muscle when contracted not only tips the head but rotates it. Most cases of wry neck are congenital, and children when born present this condition. There are other types of wry neck which are not congenital which will be considered later.

In congenital cases, the usual history has been that the deformity was present at birth, or was noticed soon after birth and increased, and the child was brought to the doctor because of the fact that the head was tipped and twisted. As time goes on, this twist and tip become more and more marked, and is followed by a certain amount of asymmetry of the face, which, if the condition is allowed to exist, becomes permanent.

The cause of congenital wry neck has not been definitely determined, but by some doctors it is supposed to be due to some injury to the sterno-cleido-mastoid muscle at birth, resulting in a hematoma in the muscle which destroys some of the muscle tissue, causing the muscle to contract as a result of scar tissue formed, and so pulls the head to one side. Another theory is that the sternal head of the muscle receives normally the smallest amount of blood furnished any other portion of the muscle, and with the head flexed and rotated in the position it would normally assume "in utero," the arterial supply is much diminished or wholly cut off, owing to pressure on the sternomastoid middle artery. This artery is a small branch from the superior thyroid artery, and is the sole source of supply to the sternal head of the sternomastoid muscle. The deformity then may be due to a markedly diminished blood supply resulting in degeneration of the muscle fibres and subsequent scar tissue formation and contraction.

In acquired types of torticollis, there are many cases which may be due to rheumatism, injuries, post-febrile conditions such as typhoid, measles, scarlet fever, but most are commonly due

to tuberculosis of the cervical vertebræ. Also enlarged cervical glands from tuberculosis, pediculosis, or tonsil infection may cause the same condition. These are not true cases of torticollis, but assume the wry neck position because of pain either in the cervical vertebræ or in the muscles of the neck, and the treatment is entirely different.

No. 10.—Left Sided Wry Neck. Note contraction of sterno-cleido-mastoid muscle.

The deformity is a characteristic one. The head is tipped to the side on which the muscle is contracted, and the chin is rotated in the opposite direction, that is, if the left sternomastoid muscle is contracted, the head is tipped to the left, and the chin is rotated to the right. Following operation on the sternomastoid muscle, the head must be put in the exactly opposite position, the head being tipped to the right as far as possible, and the chin rotated to the left. There is no pain associated with the congenital type of the deformity, and the only symptoms are those due to contraction and consequent limitation of motion. The child cannot tip the head as far as normally on the well side, and cannot rotate the head as well.

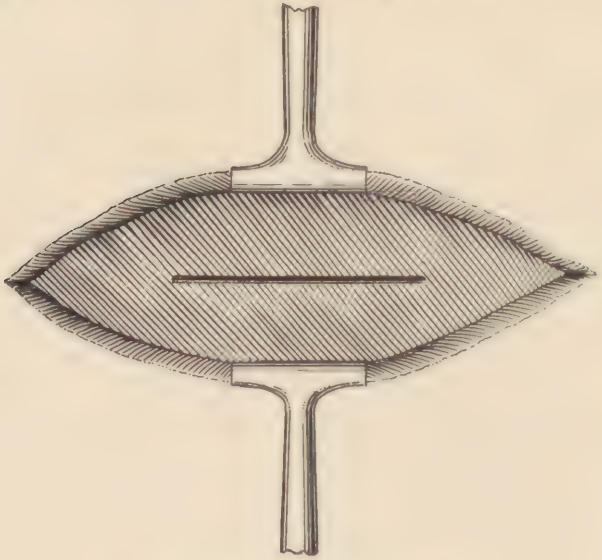
No. 11.—Torticollis. Three children in same family.

In little babies with congenital wry neck, various non-operative methods may be carried out, such as muscular stretching or massage, all used for the purpose of stretching the contracted muscle. In most cases, while this method for little babies may help, it is not usually efficient or corrective and later an operation will have to be done.

In operative methods it is necessary to expose by an incision

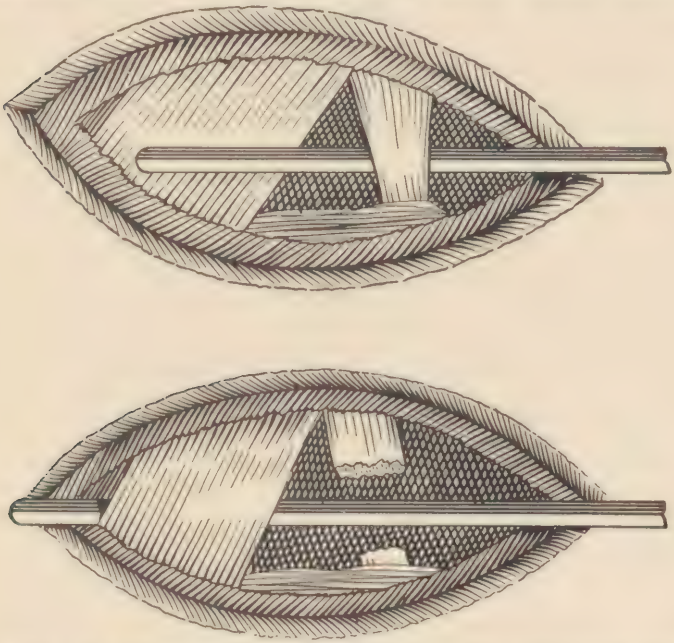
the ends of the sterno-cleido-mastoid muscle where they arise, one from the junction of the sternum and clavicle, and one from the inner third of the clavicle. Both these ends must be completely divided, following which the head is twisted and bent in the opposite direction. A plaster cast can be applied while the child is still under ether, holding the head in an over corrected position, or the child may be placed upon a Bradford frame and the corrected position of the head maintained by two straps of adhesive plaster applied as follows: one along the cheek of the well or non-operated side, passing under the chin and stretching to a cord which hangs over the side of the bed on the opposite side. The head then can be held in an over-corrected position, provided a counter

No. 12.—Torticollis. Showing line of incision in skin.



No. 13.—Incision in Fascia.

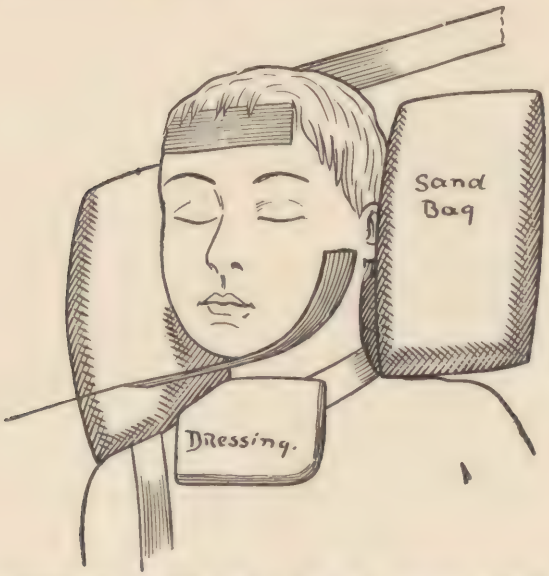
force is exerted by the second strap of adhesive plaster passing over the forehead to a weight on the other side of the bed. These two straps can be arranged in a way to cause no discomfort. They permit the dressing of the wound if that is necessary, and, secured by sand bags at both sides of the head, furnish adequate fixation of the head in a corrected position. A similar arrangement can be made with a head sling of canton flannel, fastened



os. 14 A, 14 B.—Showing Division of Sternal and Clavicular Origins.

to the head, with weights attached so as to pull the head into a corrected position, and maintain it there by weights and pulleys.

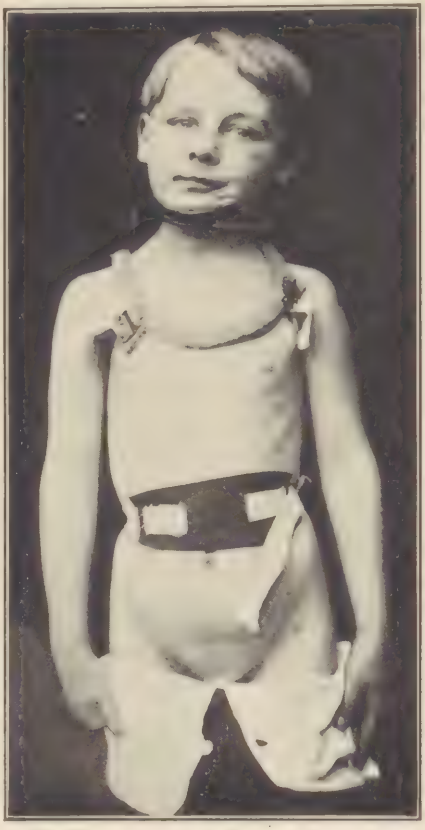
These adhesive plaster straps can be worn for a week or ten days at the end of which time the wry neck brace is to be applied, which should be worn for a period of approximately six months. If the plaster cast is applied immediately after operation, the cast is to be worn from four to six months, and the brace later applied if found necessary. It should be remembered that mere correction of a deformity similar to a wry neck is not wholly accomplished simply as a result of division of the



No. 15.—Torticollis, Right Side. Showing adhesive strap for over-correction in bed. Post-operative.

No. 16.—Torticollis. Post-operative plaster cuirasse.

muscles, whose contraction is only a small factor in the deformity, which may have existed for some time. There are other muscles deeper down which have become contracted, and if the condition has existed for any length of time, there are certain changes in the articulations of the cervical vertebræ which do not change unless the head is held in an over corrected position for a reasonably long period, to allow for changes incidental to growth. Unless these precautions are carried out, relapses will occur.

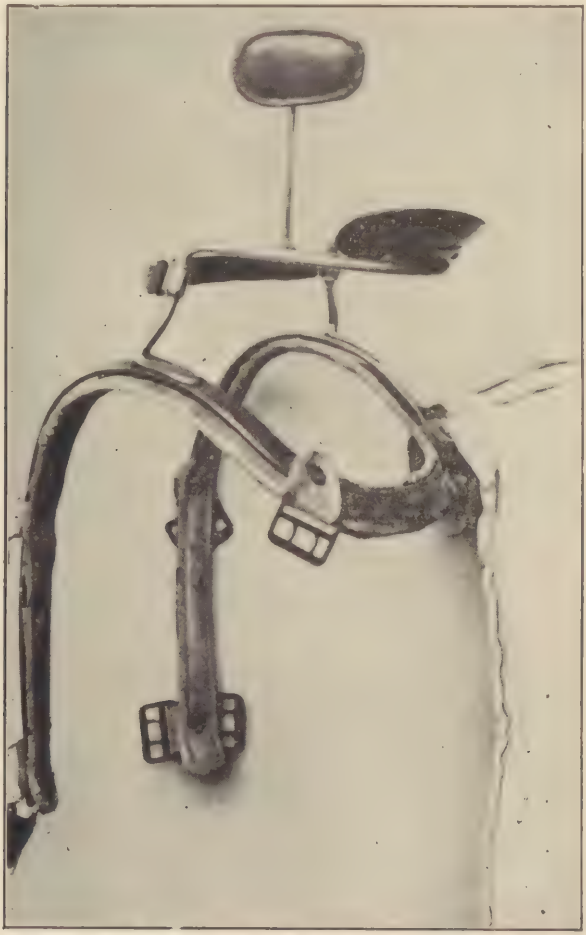


No. 17.—Front View of Wry Neck Brace for Right Torticollis. Post-operative condition with head tipped to left and rotated to right.

In the after care of these cases, first of all in plaster cases, it is essential that the nurses should see that there are no chafing spots underneath the plaster; that the child does not allow food to get inside the chin piece; that the ears are thoroughly freed, and that the plaster is cut about the ears so that there is no possibility of chafing. The top of the plaster on the head should be cut away so that the hair can be taken care of, otherwise the scalp gets into a very dirty condition. In brace cases, there is practically nothing to look after except chafing spots and proper fitting of the brace which of course has to be left to the surgeon in charge.

Spina Bifida Occulta.—Spina bifida occulta is a congenital deformity of the spine usually situated in the lumbar or dorsal

region, but occasionally in the cervical, and recognized by a vertebral cleft which may be more or less evident, involving one or more vertebræ, and without the existence of a tumor. This condition is usually associated in the dorsal and lumbar



No. 18.—Wry Neck Brace. Note chin piece and head pad.

regions with a profuse over-growth of hair which is localized over the defective arches, or may even have a wider distribution. This abnormal hair growth may be the only sign of the defect and is pathognomonic when present. It may exist at birth or may not develop until during puberty.

Accompanying this condition of defective vertebral development, and as a result of it, there may exist dislocation of the hip, club feet, partial paralysis of the lower extremities, changes in tactile and thermal sensations, anæsthesia, hyperæsthesia and trophic ulcers. These conditions are often the cause of the child being brought to the surgeon, and in examining cases which present any of these conditions, the spine should never be forgotten.

No. 19.—Case of Spina Bifida Occulta. Note hypertrichosis or overgrowth of hair in lumbar region.

These cases are congenital in origin and are not to be considered as acquired deformities of the spine. They are of a series of congenital malformations which may be due to traction of amniotic bands preventing union of the borders of the medullary groove.

Spina bifida occulta occurs not infrequently. It is often overlooked, and often individuals go through life with no knowledge of their condition. The persons who are exhibited in dime museums and at circus side-shows with long growths of hair on the back, resembling and often called a "mane," are cases of spina bifida occulta, of which this hypertrichosis is but a sign.

There may or may not be any accompanying symptoms, and, as I have said above, patients may go through life without any knowledge of their condition. If, however, a patient presents himself with dislocation of the hip, club foot, paralysis of the legs, sensory disturbances, perforating ulcers of the feet, or other trophic disturbances, it is usually wise to examine the spine carefully. Palpation, inspection and the x-ray usually are enough to give one an adequate diagnosis. If the defect is in the

cervical or upper dorsal vertebræ, there is a deformity which is at once apparent, and, when once seen, the diagnosis can be made at a glance and is never forgotten. The neck is much shortened and thickened or broadened; in fact, the patient usually gives the appearance of having no neck at all, and the head has the appearance of being set directly on the shoulders. The motion of the head and neck are necessarily limited in all directions. There may be pain associated with a bifid spine which may be constant or intermittent in character. The deformities and affections of the extremities are probably due to a general lack of development, and the pain due to the existence of a firm band of connective tissue, passing through the spinal cleft and connecting the skin over the cleft with the spinal cord near its lower end.

For the cases without complications or symptoms, there is, of course, no treatment. As the children grow older, usually some defects become apparent, manifested by the development of trophic ulcers, defect in locomotion, lateral curvature, etc. These defects usually become evident or more marked during the period of rapid growth, *i.e.*, from twelve to seventeen years. Dislocation of the hips may be reduced successfully. Pain, hyperæsthesia and anæsthesia, involving bladder and rectum, may be relieved by an operation which divides constricting bands in the vertebral cleft, and relieves the spinal cord or cauda equina from pressure. This is often followed by brilliant results. Club feet should be over corrected from the start. The treatment is wholly symptomatic. The cavities of the body, that is, thorax and abdomen, should be carefully examined for the existence of a tumor which may be the result of a ventral protusion due to a ventral defect of the spinal column. I have never seen a dorsal and a ventral defect co-existing. These latter cases, that is, ventral defects, are very rare, and those reported, which have been operated upon, have all died.

Congenital Deformities Associated with Defective Development.—There are other congenital deformities of the arms and legs to which attention should be called, namely, the child with a congenital short leg due to defective development of either the femur or the bones of the lower leg. From an ortho-

pedic point of view, these cases are not common, and from a nurse's point of view, there is very little that needs to be done for them. They are largely reconstruction problems which require years of time. The child shown in the photograph, No. 20, represents a case of defective development of the right leg with

No. 20.—Congenital Defect. Note amputation of arm on left and short leg on right.

No. 21.—Case of Congenital Absence of Tibia and Fibula.

complete absence of the arm below the elbow on the left. There is another type shown in the next photograph representing defective development of the left leg with a partial club foot. This twisted foot can be corrected, but nothing probably can be done to lengthen the leg, and the child will have to wear some sort of a splint.

Other congenital defects of the hands and feet are shown in the three following photographs: the first shows a case with

No. 22.—Congenital Deformity of Toes—So-called "Lobster Claw" Foot.

No. 23.—Case of Web Fingers.

No. 24.—Double Harelip and Congenital Deformity of Hands with Absence of Some of the Fingers.

No. 25.—Congenital Constriction Bands
Note tight band around lower right leg.

defective development of the feet, or rather the toes, resulting in a foot resembling a lobster claw. These feet are often functionally useful, but usually nothing can be done to alter the condition by surgical means. The next photograph represents a case of webbed fingers, No. 23, a common deformity, and one easily relieved by surgery. The next is a case showing a double harelip, with marked deformity of the hands. In this case only the lip defect can be repaired.

No. 26. — X-ray Showing Complete Fusion of Upper End of Radius and Ulna.

Congenital Constriction Bands.—There is another condition which exists which is known as congenital constriction bands. These constriction bands occur on the arms and on the lower legs, and are formed of strong scar-like dense tissue. They are circular, and are accompanied by very deep indentations of flesh extending down to the bone. They are supposed to be caused by amniotic adhesions. The only relief for these constriction bands is an operation, which either dissects them out completely, or divides them in such a way that the constricting properties are diminished. Even after operation they occasionally tend to recur.

Congenital Radio-Ulnar Synostosis.—Another condition occasionally seen is that known as congenital radio-ulnar synostosis, or a fusion of the two bones of the forearm in the region of the elbow. This is a congenital defect, and limits pronation and supination of the hand considerably. The only relief for this condition is an operation devised to separate the radius and ulna so that supination and pronation can occur. The condition is generally discovered promptly because it is found that the child cannot turn the palm of the hand up without outwardly

rotating the humerus to its limit, and oftentimes full supination is impossible. The accompanying x-ray shows the condition of the fusion of the two bones of the elbow.

Sprengel's Deformity or Congenital Elevation of the Scapula.—This is a condition of the shoulder blade characterized by the upward displacement of one or both scapulæ. The affected scapula is usually smaller than the normal one of the other side. The child usually presents a shoulder on one side much higher than the other, accompanied by a certain amount of lateral curvature of the spine, convex to the side of the high shoulder. The condition is purely congenital in type, and the cause of the condition is not known. Boys have it as frequently as girls, and the deformity is usually more common on the left than on the right. The only thing that can be done for the condition is to operate on the scapula, remove the deformed supraspinous portion, and anchor the tip of the scapula to the ribs, after moving it down as far as possible.

No. 27.—Sprengel's Deformity or Congenital Elevation of the Scapula. Note high small scapula.

CHAPTER II

OSTEOMYELITIS. RICKETS

Osteomyelitis.—Osteomyelitis is an acute suppurative inflammation of the bone, and secondary to an infection by some pyogenic bacteria. The process in the bone is frequently secondary to suppurative foci elsewhere, such as running ears, infection of the tonsils, pneumonia, pleurisy or empyema, scarlet fever, typhoid fever, etc. The infection is carried in the blood stream from its original source to the bone affected. The most common organism is the staphylococcus pyogenes aureus. The other two most common are the staphylococcus albus and the streptococcus pyogenes.

The disease usually occurs in children, and about one half the cases occur between the ages of 13 and 17, although it is very often seen in young children. Boys are more often affected than girls, and the condition appears to follow injury, fatigue, or exposure to cold or wet. It is more apt to occur in individuals whose bones have not fully developed, and before the diaphysis has fused with the epiphysis.

Osteomyelitis nearly always begins in the diaphysis of the bone, usually near the epiphyseal line. The femur and tibia are the bones most frequently attacked, but no bones are exempt. Usually only one bone is affected primarily, but others may be involved secondarily.

The primary area of infection is always in the bone marrow, near the epiphyseal line. The infection may extend very rapidly along the shaft of the bone, and involve the entire marrow. It may extend quite easily through the dense cortical bone, and so produces an inflammatory exudate and abscess between the periosteum and the outer layer of cortical bone. It may strip the periosteum from the entire length of the shaft. This condition may exist as early as the third or fourth day. As the periosteum is raised, new bone forms under it and around the infected

shaft. This new bone is known as the involucrum. This involucrum later develops into a new shaft or bone to take the place of the one destroyed by the infection.

No. 28.—Acute Case of Osteomyelitis of Tibia Involving Whole Shaft.

The disease usually begins with sudden local pain, generally becoming quite severe and occasionally throbbing in character. The pain is usually referred to the shaft of one of the long bones

No. 29.—Brodie's Abscess or Localized Osteomyelitis in Lower End of Tibia.

cal osteomyelitis known as Brodie's abscess which are small circumscribed areas of necrosis in the shafts of the long bones, generally in the tibia or femur, which may persist for a long time without symptoms except that the child complains of occasional pain in the leg or throb-

near the epiphyseal end. Pressing the bone with the fingers oftentimes elicits pain. Local swelling may appear early, which at first is not red but soon becomes much reddened. The adjacent joint frequently becomes tender, hot and swollen. The temperature of the child may rise to 103 or 104, and the pulse usually is rapid. There is considerable evidence of constitutional disturbance, and the child may be very sick and delirious.

There are certain types of lo-

No. 30.—Bone Cyst in Humerus Resembling Brodie's Abscess. Note lack of bone proliferation.

bing in the legs in the night. These pains are sometimes accompanied by a certain amount of local swelling over the areas of bone abscess. They may exist for years without developing further, or they may suddenly light up as a result of trauma or some other unknown cause, and go on to an acute inflammatory condition, requiring operation.

The diseases which are most frequently mistaken for osteomyelitis are early tuberculosis of the bones, acute articular rheumatism, gonorrheal rheumatism and typhoid fever. The most commonly mistaken diagnosis is acute articular rheumatism, and much valuable time is lost in the treatment of these cases by such a diagnosis.

In the acute stages where there is of course definite bone inflammation with oftentimes an abscess, the only thing to do is to operate on the part, evacuate the pus, and establish drainage. Incision down to the bone is not enough, but the exploration must be carried to the epiphyseal line which can be explored by means of a drill in order to locate the origin of the infection. Early drainage in the acute stages is absolutely essential to prevent increasing bone destruction. If drainage is not established early, acute osteomyelitis tends to become general septicemia through absorption of the toxic products. If the adjacent joint is not involved in the process, motion in the joint eventually is restored, but if the pus invades the joint, the eventual result will be a stiff joint. If drainage has been adequately insured by means of an incision, the wound may be kept washed out by a Carrel-Dakin solution, the infected part being meanwhile supported by a plaster cast, posterior wire splint, or a Thomas leg splint, in a position to prevent contracture deformities. When the disease has become subacute, the original bone becomes necrotic, and develops into a sequestrum or piece of dead bone surrounded by involucrum, which is new bone formed from the periosteum. When the sequestrum has definitely separated, it is then necessary to remove it, because if it is not removed, it simply lies in situ, acts as a foreign body, and so prevents healing. Weight bearing or functional use of the part must be prevented until the involucrum has developed sufficiently to support body weight without becoming deformed.

Rickets.—Rickets is a constitutional disease which affects young children and infants. It occurs usually in children in the first dentition period, and is closely connected with impaired nutrition. There is an alteration of the bones during the period of growth in rickets, and normal ossification does not take place, the bones remaining soft because of the fact that there is a diminution of the proper amount of lime in the bones which is deposited under normal conditions, and gives the bones their hardness. There is a very definite deficiency in the amount of inorganic phosphorus deposit, and to that deficiency is to be described the failure of the calcium deposition. It may occur in anybody's child, but is more likely to occur as the result of poor environment, improper hygiene, improper feeding, lack of exercise, fresh air and sunshine.

No. 31.—Healed Case of Osteomyelitis of Tibia Following Resection.

There is no evidence that rickets is hereditary. The early manifestations may be seen as early as the sixth month, and it rarely begins later than the third year. The first and second years seem to be the two years during which it occurs most frequently. There is no difference in the occurrence in sexes, boys and girls being equally affected. In hospital clinics in America, it occurs most commonly in Italians and colored people. It is not as common among native born Americans, except the Latin races. It is more apt to develop in late winter and spring than at any other time, and as a rule the following social factors are of

importance: the social conditions of a rachitic family are usually not so good as those of a non-rachitic. The average number of persons per room is greater, the air space is 32% less, and the home is more dirty in a rachitic family. It is evident so far as can be found out at present that rickets is a definite deficiency disease from the point of view of nutrition.

The symptoms of rickets are those of a slowly developing constitutional disease. The early symptoms are restlessness at night, profuse sweating especially of the head, constipation, capricious and impaired appetite; the child is fretful, its abdomen is prominent, and often, although the child looks fat, it is anæmic and the muscles are soft. The liver and spleen may be enlarged, the child is slow to walk, and the muscles are very much thinned out or weakened. Occasionally, although the child may be old enough to learn to walk, any attempt made to put him on his feet will cause a great deal of pain, due to the fact that the growing ends of the bones or so-called epiphyses, which undergo marked changes in rickets, are tender and soft, and therefore weight bearing causes a great deal of pain and discomfort. This condition has sometimes been confused with paralysis, and at times has been known as the "paralysis of rickets." It is not, however, a paralysis, and should not be confused with such a condition. It is merely due to tender and irritable epiphyses which are painful in attempted weight bearing.

As the disease becomes more manifest, there takes place a very definite, and at times extremely marked, enlargement of the ends of the long bones, particularly the bones of the wrist, that is, the radius and ulna; the lower end of the tibia and fibula at the ankle, and especially the fusion of the ribs with the cartilaginous extensions at the costosternal junction. This enlargement where the ribs join the sternum has become known as a rosary. This rosary can always be felt, often seen, and is much larger on the inside of the chest than on the outside. The increase of the epiphyses at the wrist is generally more noticeable than the increase in the epiphyses of the other bones of the body. This enlargement does not involve the bones, but is simply a manifestation of bone softening at the ends of the bones.

In the head, the following symptoms may be noticed: the head becomes somewhat large and square, the forehead high and oc-

casionally protruding, the skull may be thin, the anterior fontanelle often stays open until the third year, and the posterior fontanelle sometimes may remain open for months. Normally the anterior fontanelle usually closes at about the sixteenth or eighteenth month, and the posterior fontanelle usually closes after the sixth week. There occurs also in rickets a transverse depression in the chest which is known as Harrison's groove. This is due to a softening of the ribs and cartilages of the sternum, and as a result of this, the attachment of the diaphragm on the inner side of the chest pulls the ribs in at its point of attachment, and so creates a depression, which is very marked on the anterior portion of the chest. The ribs below this depression or Harrison's groove, or sulcus, flare outward so that the depression oftentimes is very marked.

No. 32.—Funnel Chest from Front

There are also two other conditions of the chest which are associated with rickets, namely, funnel chest, where there is a depression of the breast bone known as Pectus Excavatum, and another one known as chicken breast where the breast bone sticks out either definitely in the middle line or perhaps on one side more than the other. This condition is known as Pectus Carinatum. These deformities may be and often are due to bone softening of the ribs and sternum.

No. 33.—Funnel Chest from Side.

As the child gets older and as the tenderness of the epiphyses gets less,

No. 34.—Marked Case of Bow Legs.

No. 35.—Case of Moderate Knock-knee. Note flat feet and enlarged epiphyses at wrist and ankle. Note Harrison's sulcus on chest.

No. 36.—Knock-knees—One Leg More Marked Than Other.

walking is attempted. As a result of the super-incumbent weight on the legs, plus the condition of soft bones, bow legs or knock-knee may develop. Curvature of the spine may develop as a result of softening of the vertebræ, and deformities of the arms may develop. Oftentimes parents will lift the

No. 37.—Knock-knees from Front. Note overlapping of legs at knee.

child by the upper arms, and so create bowing of the humerus, or a child with a soft rachitic spine will tend to support himself by transferring the weight of his body on to his arms as he sits, and in that way will develop bowing of the arms. There is also a condition known as coxa vara in these cases of rickets, which is a depression of the neck of the femur, so that the neck of the femur instead of forming an angle of 130° or

140° to the long axis of the shaft of the femur will become depressed so that in many instances it is almost a right angle. As a result of this deformity of the neck of the femur, the trochanters are high, and the child walks with a hollow back and a waddling gait. There is considerable limitation in abduction of the legs, and the picture suggests up to a certain point that seen in cases of double congenital dislocation of the hips.

No. 38.—X-ray of Case of Rickets with Coxa Vara, or Diminution of Normal Angle of Neck of Femur with Shaft.

So far as the treatment of rickets goes, it is essential first of all that the general treatment be carried out, which is essentially dietetic and hygienic. The child should be kept in the open air and sunlight as much as possible. Simple food without too much starch can be given, particularly foods which have antiscorbutic properties. It has been found recently that cod liver oil possesses practically all the necessary elements for the cure of rickets, and five to fifteen drops of cod liver oil three times a day is usually enough in the course of a few weeks to show its effect on the bones as demonstrated by x-ray pictures. Sunlight is essential, and quite as much a part of the cure as the feeding of cod liver oil. This does not mean sunlight filtered through

1 2 3 4

No. 39.—Diagrammatic Drawing of Four Stages of Rickets from X-ray Studies. 1. Acute; 2. Sub-acute; 3. Healing, and 4. Healed. Note changes in epiphyseal line. From "Rickets," by R. W. Lovett, J.A.M.A., December 11, 1915.

No. 40.—X-ray of Knee in an Acute Case of Rickets, Showing Lack of Bone Formation in the Ends of the Femur and Tibia.

No. 41.—X-ray of Knock-knee—Not Healed.

No. 42.—X-ray of Healed Case of Rickets. Knock-knees. Note marked compensatory bends in femur and lower leg bones.

glass, but direct sunlight. Sunlight coming through glass loses its efficiency from the point of view of any curative effect.

No. 43.—Case of Anterior Bow Legs.

Treatment of the bony deformity is as follows: the child with a rachitic spine, that is, the child who has a long backward curve in the spine and who has signs and symptoms of rickets, should be kept flat on his back all the time, either on a hard hair pillow or on a Bradford frame. He should not be allowed to sit up, and should be kept in this position, except for bathing and turning, and any necessary nursing care, for a considerable period of time, preferably six months or a year.

The child that has developed knock-knees can be helped considerably in the early stages by means of knock-knee braces. These braces are to be applied and worn all the time the child is up. As a rule they are not efficient or curative particularly after the age of three or three and a half years because by that time rickets, so far as the constitutional or acute stages have gone, has tended to cure itself, and the bones are generally not soft enough to allow much correction by means of apparatus. When the bones have become sufficiently hard following the cure of rickets, and if knock-knees still exist, the only thing to do is to operate on the leg and break the bone just above the knee. The leg is then straightened, and a plaster cast is applied which is to be worn for a period of seven or eight weeks. If this operation is done too early during the subacute stage of rickets,

the deformity is almost sure to recur following resumption of weight bearing.

Many children develop bow legs as a result of rickets, and this bowing may be either lateral or anterior bowing, particularly marked generally in the lower third of the tibia. Lateral bowing

No. 44.—X-ray of Case of Anterior Bow Legs.

most marked in the tibia is the more common deformity, and more easily corrected. Up to the age of three years, bow leg braces properly applied and constantly worn will correct most of the lateral bow legs. No brace so far as I know will correct anterior bow legs to any advantage. After the child gets beyond the age of three, and bow legs either lateral or anterior still exist, an operation will have to be performed. If the child is fairly young, that is, between three and four, lateral bow legs

can be corrected by means of an osteoclast, which is a machine that breaks the legs at the point of greatest deformity, or if the bone is too hard, then an open operation has to be done. In anterior bow legs, an operation which has for its purpose the removal of a wedge of bone from the apex of the deformity is performed. Usually the result is a fairly satisfactory looking one, but one which is not always a cosmetic success, but is an improvement. So far as the life of the child with rickets goes, the prognosis is usually good. There are a great many children with a slight degree of bow legs and knock-knees who grow up without any particular deformity. The decision of operation of course in these cases has to be left to the surgeon. In walking with bow legs, the child is very apt to toe in, and has a considerable degree of waddling. In knock-knees when the child walks, there is usually a considerable degree of flat foot which may have to be corrected at the same time by means of pads in the shoes, or a lift on the shoes. If the child develops deformities of the spine as a result of rickets, these deformities have to be treated by means of plaster jackets in later stages, and by rest on the back, as previously spoken of, in the earlier cases.

CHAPTER III

SCOLIOSIS. SCHOOL SEATING. PAINFUL AND IRRITABLE BACKS

Scoliosis.—There are two varieties of lateral curvature, first, the postural or functional, and second, the organic or structural.

The first is really nothing but a faulty attitude. The child, who is generally from 5 to 15 years old, stands with a slight or very moderate lateral curve of the whole spine, in most instances to the left. The left shoulder is higher than the other, the trunk is displaced to the left, uncovering the right iliac crest, and making it more prominent than the left. There is no marked rotation or twisting of the curved region, but when the child bends forward from the hips and the trunk becomes horizontal, the right side of the back of the thorax can be seen to be very slightly higher than the left. The curve disappears when the patient lies down.

The condition is often associated with round shoulders and round back, and where statistics have been taken regarding it, it has been found to occur in from 20 to 25 per cent of the children of school age. The curve is always single, and compensatory curves do not exist. It is sometimes described as total scoliosis, which should be interpreted as being synonymous with functional or postural scoliosis.

Two mistakes are frequently made in dealing with this condition. In the first place, the curve is so slight that it is frequently overlooked, and second, if it is recognized, the parents are frequently told that the child will outgrow it. There is no reason for overlooking the existence of any postural curve, because it is perfectly simple to hang a plumb-line in the cleft of the buttocks and see if the spinous processes form a straight line under that plumb-line. If they deviate in a gradual curve, total scoliosis exists.

With regard to the second point, so far as observations go,

No. 45.—Case of Left Total Functional Scoliosis.

No. 46.—Round Hollow Back with Forward Shoulders.

No. 47.—Round Hollow Back with Forward Shoulders.

there is no tendency to spontaneous outgrowth of the condition. It is extremely common in adults, and the tendency of growth is entirely toward an increase of the deformity rather than toward a straightening of the spine. Such cases frequently change to the structural type in the process of growth, double curves forming out of single ones; but such cases do not as a rule change to the severe type of structural curves, so that having recognized the existence of a postural lateral curve, the parents should be told that it will probably increase somewhat, will undoubtedly persist into adult life unless efficiently treated, but will probably not cause serious or disabling deformity.

The treatment is simple. The general hygiene should be looked into, overwork at school and at home prevented, and if the resistance of the child is below normal, the day should be shortened slightly by a period of recumbency during the day.

The question of clothes is an important one and should be investigated. Most children of this age wear a waist with shoulder straps which rest near the tips of the shoulders. To this waist are attached the clothes and also side elastic garters running to the stockings, which are kept very tight. The tension of these elastics is transmitted by the waist to the straps over the shoulders, and the shoulders are continually pulled downward and forward. Round garters should be substituted for side elastics in these cases, the clothes suspended from the waist should be as light as possible, and in many instances they may be supported from a belt.

If there is any reason to suspect a visual error leading to an improper position in reading, the eyes should be examined and such error corrected. It is advisable in all instances to go into the question of a short leg, not by a measurement from anterior superior spine to the internal malleolus, which is of little practical value and often misleading, but by placing under the foot on the side to which the spine curves, a lift sufficient to raise the pelvis on that side and see if an improved position of the spine results. If it does, a higher sole should be worn on that side with a view to inducing a constant improvement in the spinal position.

With these preliminaries taken care of, the treatment should

consist of a special set of gymnastics which are within the range of any good teacher of gymnastics, consisting practically of a setting-up drill similar to that given to army recruits. Such patients should exercise daily for half an hour or an hour under the supervision of the teacher until they can maintain a symmetrical position for a few minutes, when they can be allowed to do the exercises at home under the supervision of a parent, and report for observation. The gymnastic work should be individual and class work discouraged.

The daily active treatment should generally not cover a period of more than from one to three weeks under favorable conditions, but the observation period should last for at least a year. Under these conditions the prognosis for a complete cure is excellent, but exercises must be done with precision and vigor, and the general condition of the child must be regarded.

Organic or Structural Lateral Curvature.—This is accompanied by changes in the spinal structure, with deformity of the vertebræ. The phenomena cannot be reproduced experimentally, and the condition is outside of the normal behavior of the spine and implies structural change. Severe cases in childhood are due to one of five causes:

1. A congenital anomaly of the spine, such as split vertebræ, defective ribs, etc., a class of cases only recently recognized as so important, and until the general use of the x-ray not generally understood.
2. Infantile paralysis.
3. Empyema.
4. Rickets.
5. A softness of the bones which we must assume without direct evidence of rickets, but in which bony deformity is so great that it is evident that the bony resistance is below the normal.

The characteristics of organic lateral curvature are definite curves, either single or double—more often the latter—and much more marked than in the postural class, in some cases running to extreme deformity. There is always a rotation of the vertebræ or horizontal twist at the site of the curve, and in bending

forward, with the trunk horizontal and the arms hanging, there is always to be seen a more or less marked prominence in the affected region on the side to which the spine curves, that is, on the convex side of the lateral curve. If the curve is double, there are two rotations corresponding to the two curves. This

No. 48.—X-ray of Case of Congenital Scoliosis Due to Defective Dorsal Vertebræ and Fused Ribs on the Left. There is apparently only a partial development of the fifth dorsal vertebra.

is a constant characteristic, and is diagnostic of this type of curvature. A right curve has always a right prominence, and vice versa on the other side. The curve does not disappear on lying down, and the x-ray shows a deformity of the vertebræ, with compression of the intervertebral disks on the concave side, and in the more advanced cases, with a wedge-shaped deformity of the vertebræ. Distortion of the figure, the elevation of one shoulder, the prominence of one ilium, a general displacement

of the body to the side, etc., are the results and expression of this bony spinal deformity.

It must be clearly recognized that these are the cases that present the difficulty in treatment, the vertebral column in these cases being deformed to some extent, with the changes mentioned, namely, shortened ligaments and muscles, compressed disks, and, in the severe cases, wedge-shaped vertebræ. In addition to these deformities to the side, the vertebræ twist on a vertical axis and are thus distorted along with the ribs and the bony structures of the thorax, which share in the deformity in severer cases. These changes in the lateral and in the horizontal direction result in distortion of the viscera, compression of the lungs, displacement of the heart and disturbance of the abdominal viscera, which in severe cases predispose to impaired digestion, deficient chest capacity, and in general to impaired resistance, so that it is safe to say that as a rule patients with severe scoliosis in adult life are badly nourished and have an impaired resistance. Extreme deformity may result in the severest cases.

Having thus defined, very briefly, the essentials of the condition, we come to the very difficult question of how such cases should be treated. As the keynote of the treatment to be advocated, we must recognize that bone is an adaptive structure, and in its growth follows the line of least resistance. We must remember also that we are dealing with a lateral bony deformity of the spine. Putting these two considerations together, it would seem as if our best chance of remedying the bony deformity was to force the spine into as normal a position as can be obtained, and to hold it in that position during part of the period of growth.

The majority of such cases in this country, as a matter of fact, are at present treated by gymnastics, and one rarely sees a bad case in which this treatment has not already been pursued and has failed. There are, apparently, two reasons for this: first, the treatment by pure gymnastics is inadequate for any but slight and moderate cases, and therefore unsuited to the treatment of severe cases; and second, in general, it is ineffectually given because the average medical gymnast thinks if he

gives a treatment which he has reason to believe is proper, his responsibility ends. He does not measure the efficiency of his treatment by the results.

Moreover, not only does gymnastic treatment in the severe grade of cases as a rule do no good, but if effectually carried out, it does harm up to a certain point by loosening up a stiff spine, and allowing the spine to sag farther into the bad position. A spine with severe lateral curvature soon becomes stiff and gets slowly worse, but if it is loosened by effective gymnastics, the side thrust of the superincumbent weight is so great that it becomes rapidly worse, and the patient's average standing position is worse than before treatment was begun.

The rule should be, therefore, either (1) not to use gymnastics alone in any but slight cases, (2) to keep the patient recumbent until the gymnastics have developed muscles as well as restored flexibility, or (3) to use a support in connection with gymnastics to hold the improved position.

The use of gymnastics alone in lateral curvature of the spine should be limited to the slighter grades of structural curves. Such gymnastics should obviously have two aims: (1) to restore flexibility, and (2) to cultivate the holding power. The exercises should be done with vigor and precision for at least an hour daily, and they are to be regarded as effective only so long as they produce manifest improvement. Gymnastic treatment should be stopped, temporarily, if the patient loses weight, becomes irritable or languid, or if the menstruation in girls becomes profuse. Until the medical profession insists on the adequate and careful performance of gymnastic treatment and limits it to suitable cases, it will fall into even greater disrepute than now.

Recognizing then the need of attacking moderate and severe lateral curvature as a bone problem, we advocate a treatment analogous to that universally recognized as effective in the cure of congenital club foot, namely, securing a proper position of the deformed structures and maintaining this position until the bones are reshaped by growth. In the treatment to be advocated for this grade of lateral curvature, no more attention in

the beginning is paid to the muscles than is the case in the treatment for club foot.

For moderate and severe structural lateral curvature, the treatment is of two kinds, either (1) by the use of a permanent corrective jacket worn for long periods, or (2) in its modified form by the use at first of a corrective jacket followed by a removable jacket and exercises.

No. 49.—Case of Structural Scoliosis.

Permanent Jackets.—The first form, the permanent forcible jacket, is better suited to hospital practice than the other. The treatment by permanent jackets is as follows: either in recumbency or in suspension, a jacket is applied to the patient, securing the best obtainable position without the use of high degrees of force. At first we used the recumbent position with considerable amounts of force, but in hospital practice sloughs occurred, and if much force was used, occasionally trouble with respiration followed, and experience has shown us that we can obtain the same efficiency without the risk by the use of smaller degrees of corrective force in the initial jacket put on in suspension.

When the jacket is hardened, it is left solid over the parts that are made prominent by the rotation, behind and in front; that is, in a right dorsal curve the right back and left front are not touched, but large windows are cut over the depressed side of the chest behind and the corresponding portion diagonally opposite in front, so that in a right dorsal curve, the left side would be cut out behind, and the right side in front. This makes it possible for the depressed parts of the chest to be expanded

by respiration, while the prominent parts are compressed. Pads of felt are now inserted between the prominent part of the chest behind and the jacket, thus making the jacket more corrective, and thicker pads are substituted each week without changing the jacket, these being drawn through without difficulty by means of a bandage. In this way, a continual diagonal side-

No. 50.—Structural Scoliosis Due to Rickets.

pressure is kept up on the curved portion of the spine and is steadily increased. At the end of two or three months, it will be found that it is advisable to apply a new jacket, to cut it out in the same way, and to begin on the progressive padding. The use of such a permanent jacket is continued for a period of from one to two years, being changed at intervals when it has become no longer efficient, and at the end of this time a removable jacket is substituted for the permanent one, and gymnastic treatment is begun. The removable jacket is then gradually discontinued

No. 51.—Same Case of Structural Scoliosis in Permanent Jacket Showing Window Cut Posteriorally to Allow for Expansion, Two Years Later.

No. 52.—Rotation Deformity of Ribs Shown in Forward Bent Position.

while the patient's muscular condition is being improved by gymnastic exercises.

Removable Jackets.—As in the former method, the second treatment, that by removable jackets, is started by the application of a forcible jacket either in recumbency or suspension. This is followed by a second jacket at an interval of a week.

No. 53.—Preliminary Cast for Making Removable Jacket.

After the application of the second jacket, the patient is suspended and a plaster jacket is applied which is immediately cut off to serve as a mold, and a third forcible jacket is applied to be worn while the removable apparatus is being made. The jacket which is to serve as a mold is then bound together and filled with plaster of Paris and water, a torso thus being obtained. This torso is then remodeled by cutting off on the prominent side and building up on the other side, until it has become decidedly more symmetrical than the patient. It may

also be sawed in halves at the waist and set apart about an inch in order to secure continued extension.

On this corrected torso, a plaster jacket is applied which is to be the removable jacket worn by the patient. This removable jacket should be supplied with shoulder pads to hold the shoulders in position, and should open down the front, being supplied with buckles and straps or lacings. It may also be advisable to slash such jackets over the iliac crest. This jacket is to be worn by the patient night and day, and to be removed

No. 54.—Torso from Cast. Dark plaster represents plaster added to correct deformity.

No. 55.—Cast Cut in Halves, and Set Apart to Increase Waist Line.

only for the exercise period, which should consist of one hour or more daily, the exercises being of the type mentioned above. When the jacket is applied, it is sprung open and slipped on the patient, who then lies on the back, and the arms and legs pulled on to extend the spine. It is then buckled tightly in place before the patient stands up.

Jackets of either kind should be tested for efficiency by measuring the height of the patient with and without the jacket. Without the jacket, the patient places the hands on the hips and pushes up, making himself as tall as possible, and his height is

taken in this position. The jacket is then applied and the patient's height is again taken. If the jacket does not hold him in as good a position, as estimated by height, as the patient can possibly assume with the hands on the hips, it is discarded and a more corrective one is made. In these jackets, it is often advisable to cut the windows as in the permanent form, and to use padding in addition to the correction of the torso.

No. 56.—Removable Jacket with Shoulder Pad Made Over Cast Shown in Last Picture.

If such a jacket is worn by a patient who is making good progress, in a few weeks from the beginning of treatment it will be found to be inefficient and not to be holding him on account of his improvement. Under these conditions, the torso must be again remodeled, more cut away from the prominent side, and greater pressure exerted. In the course of a year, probably two or three such remodelings would be required. These jackets may be made of leather or celluloid if preferred rather than plaster, but the plaster is perfectly efficient, although heavier.

This treatment is more acceptable than the former to private patients, and where the patient is under complete control, it is probably nearly as efficient as the other, although perhaps taking a little longer time. When such treatment as the latter has been continued over a period of a year or more in the severer cases, a trial may be made of removing the jacket for a short period each day and watching the patient during this period, the jacket being gradually abandoned as the patient's corrective power increases. In neither form of treatment in severe scoliosis is the treatment likely to last less than two years, although in the

moderate forms it may take less time to secure the desired results. It is possible to state that if the treatment is stopped half way, immediate relapse follows and nothing is gained, but if the treatment is persisted in until the end, and gradually discontinued, it seems likely that the result obtained will be permanent.

No. 57.—Same Jacket on Child with Window Cut Out Over Hollow Side to Allow for Expansion.

The Relation of Scoliosis to School Seating.—School life is to a certain extent an artificial one for the growing child, whose normal growth depends considerably on its muscular activity. The child entering in ordinary school undergoes a physical as well as a psychical depression. Schoolroom discipline naturally tends to check this muscular activity, which in turn tends to develop muscular fatigue, resulting in, or causing bad postures, nervous tension, strain, and exhaustion.

In fact the school life of a child has a very real and important influence in direct relation to its physical development. School deformities are usually due to, or if present, increased by prolonged sitting in faulty positions, combined with too little muscular activity. It is thought, however, by many observers that faulty postures alone are not enough to cause marked structural deformities; but given conditions in the child which imply lack of bone or muscle resistance, the deformity—more or less severe—may develop. Anything which reduces the general

vigor and health of the child will consequently decrease its resistance to abnormal and long continued strain.

The common type of school deformity is, however, not a severe structural scoliosis, but generally a so-called functional or false scoliosis, generally convex to the left. Variations in the antero-posterior plane are also very common. These latter variations may be classified under the following headings, namely: Round Shoulders, Forward Shoulders and Round Back; Round Back and Round Hollow Back with Forward Shoulders.

Round shoulders is the condition commonly seen where the head is carried forward, together with an increase backward of the normal physiological dorsal curve, with drooping shoulders, flat chest, and protuberant abdomen.

Forward shoulders and round back is simply an exaggerated condition of the foregoing.

Round back is a condition somewhat similar to the foregoing conditions, but where the increased backward dorsal curve is the predominant factor.

Round hollow back and forward shoulders. It is similar to the other conditions, but is accompanied by a marked increase in the normal lumbar lordosis.

These conditions may be due to too much study and too much indoor life after school life. Carrying many books home for study has also been suggested as a cause for lateral curvature tendencies, in that in New York the grammar school children habitually carry five pounds of books to and from school. This weight carried daily in one hand, or over one shoulder, exerts a distinct tendency to deformation. The schools are probably less to blame for the occurrence of lateral curvature than is generally believed; even with the most complete development of school hygiene, lateral curvature will not altogether disappear in school children, for the tendencies are probably implanted before the school life begins. It has been shown that twenty-five per cent of the school children in Germany, for example, hold themselves crooked.

In the absence of direct pathological causes, it is believed that the chief factor in the production of faulty postures is fatigue of the back muscles, resulting in the assumption of a

position which, taken originally to relieve strain, becomes habitual, and finally, owing to structural changes, permanent. Such fatigue usually results from prolonged standing and sitting rather than from active exercises. The fact that in all cases subjected to these same conditions of strain, curvatures do not develop shows that individual predisposition also plays a part. Other conditions may cause bad postures, such as unequal hearing, which causes tilting of the head habitually to one side, as will also poor or unequal vision.

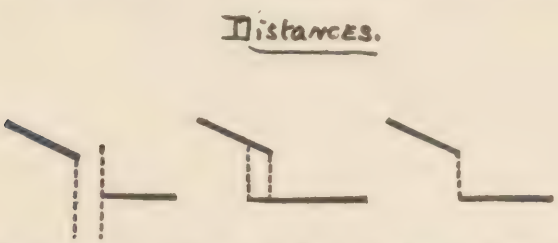
In writing, the position should be a good one, *i.e.*, with the back straight and the shoulders even, with the child directly facing the desk. The child should sit squarely in the seat, with the whole forearm resting on the desk, the elbow near the lower right hand corner.

Physical Education and Hygiene.—School children should not be required to remain sitting for long periods, and while sitting the back should be supported in such a way as to relieve the muscles from undue strain and stretching forces. It is therefore obvious that the first aim of any adequate treatment is to secure rest of the muscles. This may be done by frequent exercise periods of short duration, and by proper seating, as obtained by the proper relation of the desk and chair to the individual, combined with proper support to the back in a normal sitting position. An exercise period of three to five minutes at the end of each hour, or even at the end of every two hours, may be enough to counteract deleterious effects of the school desk and chair, and of too long rest in a bad posture. Improper attitudes invariably result from fatigue; and that fatigue must always follow any attitude which is maintained without change for any length of time, is obvious.

School departments in all the various cities of this country are alive to the necessity of the establishment of departments of physical education and school hygiene, combined properly with the development of athletics in the schools. Many such departments are now established under the charge of a competent instructor for both girls and boys, who not only conducts routine setting up drills, but is also on the lookout for postural or structural deformities of the spine. This instructor should

be versed sufficiently in corrective work to undertake the care herself, or to know enough to send the case to some one who can handle it.

School Furniture.—The question of school furniture has been before the public for some seventy years, having originated with Barnard in 1842, and about 150 models of desks and chairs have been advocated. At present a great number of American school children are sitting in chairs which give no support or inadequate support to the back in any attitude they may assume, and at desks which are not adjusted either to the proper height or at a proper distance (plus or minus) in relation to the child's needs. To be sure, many cities are now using adjustable furniture. It is a fact, however, that in many schools, benches with



No. 58.—Showing Arrangement of Seat to Desk. 1. Plus distance. 2. Minus distance. 3. Zero distance.

and without backs, kitchen chairs, and single and double settee seats are found in common use, much to the detriment of the pupils' proper physical development.

Adjustable furniture is rarely used altogether in all schools, many departments being content (where any is used) to limit their equipment of this type to a percentage of twenty-five or even fifteen. Many schoolrooms have but one row of eight desks and chairs of the adjustable type.

It is also true that no matter how much adjustable furniture is installed, it is no better than the old chairs or benches unless it is adjusted. That is, each pupil should be fitted to the seat and desk in a proper relation.

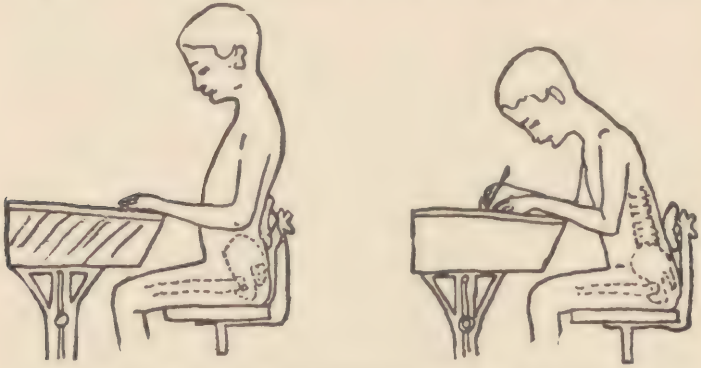
The reasons for adjustable furniture, provided it is adjusted, may be seen from the following statements: Conditions have been noted where children differing seven years in age and

twenty-two inches in height have been found sitting in similar seats and at similarly arranged desks. These conditions, I ven-

No. 59 A.—Showing Unnecessary Support Above Hollow of Back Contributes to Slouching.

No. 59 B. — Showing Chair and Desk Too Small for Large Child, Which Condition Allows Nothing but Bad Posture.

ture to say, could be duplicated in many schoolhouses in this country where no opportunity exists to adapt the individual



No. 59 C.—Boston School House Commission Chair and Desk.

pupil's size to the desk and chair in their proper relations: either the desk is too high and the chair too low, or vice versa. The desk may also be too far away from the seat—a too great plus

distance; or too near—a too great minus distance; causing undue stretching of the back muscles in the first instance, and a cramped position in the second.

Proper Relations of Seat and Desk to Pupil.—School desks should leave room enough for the knees, and should be low enough so that the elbow and forearm may rest comfortably on it without bending the back. The slope of the desk theoretically should be about 30°; but as that is too steep an angle to allow books and papers to rest on it without sliding off, a compromise

No. 60.—Chandler Adjustable Desk with the Boston Chair.

angle of from 12° to 15° has been selected. The seat should be no wider than the width of the hip, for wider seats predispose to slouchy attitudes. It should be about two-thirds the length of the thigh. It may or may not slope very slightly backward, but this is of no great importance. Any great slope is distinctly bad. The height from the floor should be such as to allow the feet to rest equally and comfortably on the floor. A seat of too great breadth, as well as one of too great depth, compels bad postures. The seat should have a back which supports the lumbar spine when sitting, at work, as well as at rest.

For standard use, the front edge of the seat should be about one inch behind the front edge of the desk—a so-called plus

distance of one inch. The back of the chair should be either straight up and down or sloping very slightly backward, and should support the spine in the lumbar region. The lower edge of the support should come about one inch above the hip bones. Any support above the hollow of the back is superfluous, and often of distinct disadvantage in that it offers a support for the common slouching attitudes seen in children when sitting on the forward edge of the seat, the spine bowing backward between the lower end and the top of the shoulder blades.

The back should give plenty of clear room at its lower portion for the buttocks and clothes; otherwise, the child will be cramped and pushed forward in the chair.

The essential features in adjustable school furniture are as follows:

1. Adjustment for height, vertically, of chairs.
2. Adjustment for height, vertically, of desks.
3. A back rest of proper inclination, with adequate support for the lower back.
4. A proper depth of seat.
5. A proper slope of seat.
6. An adjustment of desk or chair for plus or minus distance.

Painful and Irritable Backs.—Painful and irritable backs are most common in the usual run of medical practice, without a history of accident or trauma, and these are the cases I want especially to call to your attention. In fact there are few diseases in which backache does not occur. The condition is attributed to the kidneys by the kidney pill man, and to the feet by the maker of orthopedic shoes, as well as to other ills which flesh is heir to by the person who may happen to have an infallible remedy for that particular ill. It is a much neglected subject, and it is not surprising that many cases drift about to become the prey of the patent medicine man, because of lack of adequate examination and definite checking up of the patient's symptoms, history, and posture. I say this advisedly because so many cases can be so easily relieved by simple treatment.

Now, what is meant by a painful or irritable back. It is this: a person complains of pain in the back, generally situated low down, that is, at or below the dorso-lumbar junction, and of

constant or intermittent duration. Associated with this pain there may be a dragging feeling in the lower back, which may be worse after walking or standing, but may be present only when sitting, and is relieved by walking about.

There may be tenderness—generally vague—extending from the sacro-iliac joints, which are at times the points of greatest tenderness, to the shoulder blades and the back of the neck. At times this pain extends to the legs, down the back of the thighs, accompanied by a feeling of numbness in the legs, which is best expressed by the patients themselves as a sort of "woodeny feeling." Following trauma the tenderness is generally localized at the site of the injury and may be accompanied by more or less muscle spasm.

There are three large groups of cases which can be readily differentiated at once as having definite conditions which may cause backache. These are as follows:

1. *Arthritis of the spine.* This condition is often seen and is a painful and persistent condition. It has its periods of remission and exacerbation, until such a time as the vertebræ become fused, when the painful joints in the spine no longer exist and the cause of the pain is removed, namely, motion between irritable joint surfaces. This condition generally exists with other definite signs of arthritis, may occur spontaneously, or may be present even without symptoms, until some strain or trauma lights the process up, and results in great and persistent disability. Arthritis of the spine occurs most often at or after middle age, and is apt to appear in the laboring man as well as the desk worker. It is not uncommon, on taking an x-ray of a laborer's back, following an injury, to find a considerable degree of hypertrophic arthritis already present, which has been aggravated, at least symptomatically, by the accident, and consequently prolongs his disability.

Treatment in these arthritis cases generally resolves itself into the application of a plaster jacket, a backbrace, or canvas corset—any one of which may have to be worn for an indefinite period to insure adequate fixation to the spinal joints. A diagnosis of arthritis of the spine without an x-ray in a given case is not impossible, and at times easy. The back is stiff to bending

in any direction, the onset may be sudden or gradual, and the disability is great. The cause may be infectious or occupational. The progress towards recovery is slow, even with good treatment.

2. *Traumatism.* Traumatism, a very frequent cause of a painful back, especially in the industrial classes, is a most common cause of litigation and is a condition about which an impartial physician finds it very difficult to arrive at any absolute hard and fast opinion. There is no doubt about the trauma—either direct or indirect—the question is, what damage has that trauma caused? Is there a muscle sprain, a ligamentous tear, a sacro-iliac sprain, a fractured transverse process, or a crushed vertebra? An x-ray may clear up some of the bony injuries, but will not help, except in a negative way, the soft part ones. If the condition is a muscle sprain, the history will be of value. How did the pain start? What was the patient doing when it began? Certain of my cases have had sudden pain in the back when trying to lift a barrel of ashes or when lifting other heavy objects. They felt, as they said, something give way in the back. Generally the pain is in the lumbar region in these cases. There may be localized tenderness over the spinal muscles, and at times the soreness extends around into the flank. I believe the majority of these cases are ones in which a muscle fiber or fibers are torn, and, generally, strapping and hot applications, with early use, will effect a cure. Ligamentous tears act in about the same way, are generally of longer duration, and the pain and soreness are deeper seated. Ligamentous tears may be situated in the region of the sacro-iliac joint and so confuse the diagnosis. The ligamentous insertions of the great back muscles in the region of the sacro-iliac joint often lead to doubt and confusion when an injury is localized there. They do not get well as quickly, and heavy work in the future is apt to produce soreness and lameness at the same spot. The treatment in general is the same.

A fractured transverse process is not an uncommon result of having objects fall on the back, or of being thrown against something solid and striking the back. Three recent cases I have seen occurred as follows: one had a pulley block fall and strike him on the back, and break the transverse process of the

second lumbar vertebra. Another was a car conductor who was thrown against a car door when the car started suddenly. The third was run over by a team and had all the transverse processes on one side of his lumbar spine broken. Direct and not indirect violence is usually the determining cause. The pain at first is considerable—marked localized tenderness is present, motion is considerably restricted, and as a rule strapping and, later, baking and massage effect a cure, so that work is resumed in three to four weeks. Complete relief from pain and soreness may not be obtained, however, for months. There are several other bony conditions which may cause low back pain of which I wish to speak. They are usually associated with trauma and present, clinically, only painful and irritable backs, associated with disability.

The first type is seen usually following falls of some violence, as falls down elevator wells, being thrown out of a carriage or hammock, etc. Clinically there is generally an increase in the normal lumbar lordosis or hollow back, pain and numbness may exist in the legs, and the individual is considerably incapacitated, with a very rigid spine. Examination shows a prominent sacrum, and in palpation of it the fingers slip on to a sort of shelf at the junction of the sacrum and the fifth lumbar vertebra. X-rays show that in these cases there has been a definite slipping forward of the fifth lumbar vertebra on its articulation with the sacrum, resulting in some cases in definite cord pressure symptoms. A lateral x-ray will show this defect very well. Treatment should be directed to support of the spine, by braces or jackets. Some cases have been relieved by a bone graft operation to fix the slipping fifth lumbar vertebra to the vertebra above and the sacrum below, and so give relief. The condition is known as traumatic spondylolisthesis. The second so-called bony cause of back pain is one which, to my mind, is not yet proven, according to the English jury verdict. Certain observers have stated that a long transverse process of the fifth lumbar vertebra causes pain in the back by impinging on the crest of the ilium, and have shown x-rays apparently showing this condition. Certain cases have been operated on with relief by removing the offending process. It is not yet clear to my mind whether

rest in bed for several weeks or removal of the process caused the cure. The operation is difficult and dangerous. If you recall the anatomy of the region, you will remember that the transverse process of the fifth lumbar vertebra is situated well in front of the plane of the crest of the ilium, and as increased lordosis (which is said to cause the impingement), increases also the distance between these two bones, I fail to see just how anything but inaccurate observation, or an enthusiastic operator, could attribute pain and disability to such a cause in the absence of anything but definite congenital malformation.

3. The third class of cases, generally recognized as such, but often associated with definite orthopedic defects, is that where displacement of the pelvic organs in women is at fault.

Hutchins[1] believes that an anteposition of the uterus, associated with a descent of the cervix, and so resulting in an engorgement of the ovaries and their veins, is a frequent cause of backache.

Graves,[2] on the other hand, found that 76 per cent of 500 cases had backache associated with retro-displacement of the uterus, and a corrective operation for this condition relieved or benefited 86 per cent of 263 cases he could trace.

MacFarlane[3] stated that 16 per cent of 938 gynecologic cases complained of backache. The pelvic findings in 159 of these cases comprised chiefly lacerations, retroversions, prolapse, and inflammatory conditions, such as adherent appendages and endocervicitis. The incidence of marked nervousness in these 159 patients with backache was about 9.3 per cent, or about equal to the incidence of adherent appendages, and half as frequent as that of prolapse. She thinks that the neurasthenic state predisposes to backache of pelvic origin by lowering the resistance of the central nervous system. The fact that the backache was permanently relieved by appropriate gynecologic

[1] Hutchins, H. T.: "The Rôle of the Anteposed Uterus in the Causation of Backache and Pelvic Symptoms." *J.A.M.A.*, Sept. 23, 1916, Vol. LXVII, No. 13.

[2] Graves, W. P.: *Amer. Jour. Orth. Sur.*, Dec., 1917, Vol. XV, No. 12.

[3] MacFarlane, Catharine: *J.A.M.A.*, March 31, 1917, Vol. LXVIII, No. 13, p. 1000.

treatment led to the belief that these backaches were caused by the pelvic condition. Here you have three authorities all agreeing that pelvic conditions cause backache.

One point of interest and importance which Graves makes is that uterine back pain is invariably confined to the sacral or very low lumbar regions.

On the other hand, operations performed to correct pelvic displacement because of backache often fail because the orthopedic or postural defects of the individual are not corrected. It is fair to presume in a certain number of cases that, had orthopedic measures been carried out first, the operation would not have been necessary.

We now come to a large group of cases which do not fall under any of these previous classes mentioned, but which are very common. These cases may be subdivided into two classes, namely, (1) static or postural strain, and (2) sacro-iliac strain.

This brings us to the definition of what is meant by this classification, and I will take them up, therefore, in order.

1. Static or postural strain, not the result of trauma. In an important and interesting paper several years ago, Reynolds and Lovett [4] determined the center of gravity of the human body in the upright position, and noted various changes from the normal, and their effects on the posture and musculature. They showed that a forward displacement of the center of gravity put increased work and strain on the back muscles, which, if sufficiently long continued, produced backache and strain; and arrived at the conclusion, from their experimental work, that static backache was the result of definite mechanical defects in the posture.

Now, you know that normally in the upright position an individual, when at rest, is supposed to carry his weight on his bones, and not on his muscles or ligaments. The center of gravity generally falls in a line running from the tip of the mastoid, through the front of the shoulder, great trochanter, just back of the patella, and about an inch in front of the external malleolus. Any variation from this normal implies muscle and ligamentous strain and so pain—therefore, when a

[4] Reynolds, E., and Lovett, R. W., *J.A.M.A.*, March 26, 1910.

person habitually stands with the body in a position of poor posture, there is created a lack of normal muscle balance and consequently muscle strain, which is translated into pain. The so-called "carrying posture" is a good example of poor standing position. Here the trunk is carried back over the pelvis, the back is rounded and the abdomen protuberant, the low back hollow or flat. Poor postures are seen many times in poorly nourished young people who stand with a slight lateral curvature and a round back and shoulders, and who complain of backache. Other types are those individuals, women especially, who present on examination a hollow back with a marked increase in the normal inclination of the pelvis. Often there is a moderate degree of tenderness along the back muscles and over the sacro-iliac joints. A large number of these latter type of cases complain also of vague pains in the legs and feet. Into this class can be put also those obese individuals who have to lean back to balance themselves, and so by constantly putting extra work on their back muscles, tire them out, stretch their back ligaments, and so strain their ligamentous insertions, and may strain the sacro-iliac joints. These are best treated by a corset or belt which holds up the abdomen, takes the strain off the back and puts it on a brace or corset. An examination should be made in all cases to determine whether or not there is a short leg, for many cases of backache are due to an unrecognized short leg, and can be cured by making the short leg as long as the other one.

One other point of the greatest importance is the presence or absence of a short or tight heel cord. Normally the foot should go about 10° beyond a right angle in dorsal flexion, but you will find that in many of these indefinite backache cases, dorsal flexion even to a right angle is not possible, and an attempt dorsally to flex the foot causes pain all along the back of the leg, even extending to the buttock and back. This condition is probably part and parcel of the whole lack of proper muscle balance and posture, but its correction alone will often cure a troublesome and persistent backache. Associated with these tight heel cords, are often feet which are the reverse of flat, in that they present high arches and painful callosities on the

balls of the feet. Stretching the heel cords several times, which relieves the so-called "woodeny" feeling in the legs, with a specially designed machine, and taking the weight off the balls of the foot by means of a plate or an anterior heel, consisting of a lift half an inch wide by an eighth to half an inch thick, running across the sole of the shoe, just behind the ball of the feet, often gives relief. This acts as a wedge at that point and causes plantar flexion of the toes, elevation of the metatarso-phalangeal joint, and so relieves pain and pressure at that point. Raising the heels of the shoes will do several things: first, it will generally please the ladies who dread a low-heeled sensible shoe; therefore their pride is appeased, and they begin to think that you are really quite sensible. Second, by so doing, you are taking the strain off the tight gastrocnemius muscle, and so relieving pain, and third, you are tipping the body back as a whole and consequently are relieving the tension on the irritated erector spinae group of muscles, and letting up on their bow-string tension. The effect of these simple remedies in suitable cases is remarkable, and the relief from pain and discomfort marked often in 24 hours.

Certain patients I have seen always develop exquisitely tender areas about the buttocks and anus, when their posterior musculature becomes too tight, and one even develops, regularly, anal fissures which promptly clear up after stretching. It is needless to add that proper corsets, which support the strained back muscles and the abdomen well, should be supplied to all these cases. Such a corset should be no longer than the trochanter, should grip the pelvis firmly, should fit the back well, should be no higher than the tip of the shoulder blades behind, and the lower ribs in front. It is better back-laced, and should have a flat abdomen.

The above type is common, and I believe they are often called cases of sacro-iliac strain, whereas, to my mind, they have no such condition. If they have the maximum amount of their discomfort over one or both sacro-iliac joints, associated with these other conditions, I believe that it has simply happened that the maximum strain has localized there, and that a strain of the sacro-iliac joint has developed secondarily, and is not primary.

They will get well under the above course to treatment plus rest and, later, exercises and massage.

There are also many cases of backache seen in poorly developed individuals, whose musculature is poor, whose resistance is low, and whose bodily posture is bad. These cases are the result of the same chain of events—namely, poor posture and lack of muscle development and balance, and are to be treated along the more general line of developmental work. Many neurasthenics come into this class, but as a rule the backache seen in them is one which is distributed generally all over the back and rarely localized in any one spot.

Sacro-Iliac Strain or Sprain.—This last class has been before us for a reasonably long time, and has been a popular one in which to put all cases of low backache. The joints have been there anatomically, the tenderness and pain has been situated at or about the joints at the examination, and the diagnosis satisfies both the doctor and the patient.

Now it is not to be denied that the sacro-iliac joints are real joints and are subject to such sprains and diseases as are other joints, but that all low backaches should come from these joints seems too good to be true. I think that the explanation offered above in the description of the postural backaches covers a good many so-called sacro-iliac strains. The strains and slippings of the sacro-iliac joint during and following pregnancy are common in everyone's experience, and can generally be relieved by proper strapping and a good corset. One word of caution about strapping: always carry the plaster from in front of the anterior superior spine on one side, to in front on the other, pulling it as hard as you can. Also put a felt pad about half an inch thick over the sacrum, extending up the lumbar spine, and you will get better results. Most strapping, as I see it, is inefficiently applied.

Sprains of the sacro-iliac joints are seen after sudden wrenches, especially when the person is bent forward and to the side. They seem to follow twisting strains rather than direct ones, either in the upright or flexed position. Certain cases are accompanied by local swelling and tenderness, and, although increased motion and slipping can rarely be detected, and the

x-rays invariably, in my experience, prove negative, there is no doubt as to the condition. Associated with these sacro-iliac strains, one usually finds more or less pain and discomfort down the back of the leg on the affected side, extending often to the foot and calf. As the condition in the joint improves, this pain in the leg gets well. This is attributed to the pressure on the nerves of the sacral plexus, which lie on the anterior surface of the joint in the pelvis, as shown by Albee [5] and others. This nerve involvement is, I believe, not due to a pressure of the slipping joint, which cannot slip enough to cause such pressure, but may be due to local congestion which involves the tissues about the sacral cord. Slipping in the joint is, I believe, rare in the usual run of cases, and is observed only in those cases where ligamentous relaxation is great, such as is seen after pregnancy and in certain other cases of long duration of poor posture and back strain in rather fat people. I have seen only two such cases where the slipping could be felt, both in obese washerwomen, who were so incapacitated, finally, that in order to get out of bed, they had to roll on to the floor, and then climb up on themselves much in the same way as a case of Pott's disease or progressive muscular atrophy gets up from the prone position. They were both promptly relieved by strapping and, later, corsets. Certain cases of acute sacro-iliac sprain, often seen following exposure and resembling an infectious or rheumatic attack, exhibit the greatest degree of pain and disability. Slipping of the joint cannot be demonstrated, but is felt and described by the patient when it occurs, generally with a twist of the body; the pain is excruciating and often accompanied with nausea or faintness. There is generally some pain down the leg on the affected side, and local tenderness over the joint. There is no mistaking these cases, for the picture is generally complete. Salicylates, rest and strapping often give relief in a few days, plus manipulation in a certain number of cases.

There are two other points in connection with sacro-iliac slipping—relaxation and strain—which I wish to emphasize. First, when there is a real looseness or sprain of these joints,

[5] Albee, Fred H.: "Study of the Anatomy and Clinical Importance of the Sacro-Iliac Joint," *J.A.M.A.*, Oct. 16, 1909, Vol. LIII, p. 1273.

the patient always states that he feels as if he were "breaking in two." This is a common statement and I believe applied to no other condition. Second, in regard to the so-called leg-raising test, so commonly used, I believe it is fallacious, for this reason: any injury to the lower back which results in back strain causes muscle irritability, which of itself will limit leg raising with the lower leg extended. This is especially true in the static type of cases and should no more be regarded as a sign of sacro-iliac strain than of flat foot. It is too frequently associated with other back conditions to be pathognomonic of any one of them.

A word of caution about back pain—never be content with an examination which does not include an x-ray, especially in cases of trauma. It is not difficult to have one made, and will reduce the percentage of guessing and raise the percentage of correct diagnoses.

CHAPTER IV

TUBERCULOSIS OF THE SPINE. TUBERCULOSIS OF THE HIP. TUBERCULOSIS OF THE KNEE. TUBERCULOSIS OF THE ANKLE. TUBERCULOSIS OF THE SHOULDER. TUBERCULOSIS OF THE ELBOW. TUBERCULOSIS OF THE WRIST

Tuberculosis of the Spine.—Tuberculosis of the spine is commonly called Pott's disease, or caries of the vertebræ. It is called Pott's disease after Sir Percival Pott, who first described the condition in 1779. It is a chronic destructive ostitis, due to invasion of the tubercle bacillus, of the bodies of the vertebræ which form the anterior or weight supporting portion of the spinal column. This destructive ostitis leads to the formation of a knuckle on the spine, or angular projection backward at the site of the disease. It is often accompanied by pain and paralysis.

Tuberculosis of the spine is of more common occurrence than tuberculosis in any other joint, and is much more frequent from the third to the tenth year than in any other period of childhood. It may, however, appear at any age in childhood, and is not seldom seen in adults.

To understand tuberculous disease of the spine, it is necessary to remember the construction of the spine: there are 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal vertebræ. We have to deal with joints or surfaces which are separated from each other by a disk of fibro-cartilage, the so-called intervertebral disk, where there is very little motion; so that the symptoms are quite different from those of general joint disease.

A vertebra is composed of a body, the center of which is filled with a fine network of bone fibres running in all directions, but with a boundary of a hard thick layer of bone. These two segments of bone are joined by cartilage to the adjacent vertebra with strong ligaments, and there is very little motion between them. Tuberculosis starts as a focus in the body of the vertebra, and the disease may spread very rapidly. The meshes and

fibres of the vertebral body being so delicate and open, there is little or no resistance to extension, and the disease may spread rapidly from one body to the next. The body of the vertebra is the part that bears the weight of the trunk, and when that is

No. 61.—Tubercular Spine from Behind. Note knuckle and collapse of trunk.

No. 62.—Same Case from Side. Note collapse of ribs into pelvis.

diseased and consequently crumbles away, you can well see how the spine bends or collapses forward to make the knuckle behind. Sometimes two or three bodies may be entirely obliterated, and the greater the destruction, the greater the knuckle. There may be no limit to the extension of the disease. If the disease involves the body of a vertebra more on the side than in the middle, there may be a lateral bend or distortion of the spine as well.

When the disease extends to the walls of the spinal canal or the canal is diminished in size by the knuckling of the vertebræ, pressure on the spinal cord may occur, which leads to paraplegia or paralysis of both legs.

Tuberculosis may appear in any section of the spine, but is more commonly seen in the thoracic vertebræ, especially the lower half. Next in frequency in involvement is the lumbar region, and last the cervical. The reason for the greater frequency of the disease in the thoracic region may be due to the fact that the lower portion of this area is subjected to greater motion and strain than other parts of the spine, and so offers a more fertile field for the invasion of the tubercle bacillus.

No. 63.—Earlier Stage of Dorsal Pott's Disease. Note child is supporting trunk on hands.

Commonly the first symptom noted is a lump on the back. This lump or knuckle does not appear until there has been enough destruction of one or more vertebral bodies to cause a collapse, and bending of the spine forward above the area of disease, and where it is present, it is evidence of considerable duration of the process. Before the onset of the knuckle, however, many children show signs of tiring easily, do not want to walk or stand, wish to be held in the parent's arms or lap, and to be carried. They also complain of vague pains in the back, legs and abdomen. In walking, the movements are guarded, the gait is like the so-called "military gait," stiff-backed. Bending of the spine

is painful and often impossible, and in getting up from a lying position, the child supports the weight of the trunk on the knees with his hands and arms. In sitting, he will also use the arms to support himself, and so take the weight of the head and shoulders off the affected area in the back.

When the disease is in the cervical region, one will often see the child supporting the head with the hand under the chin. In disease in the cervical region, the motions of the head are

No. 64.—Tuberculosis of the Spine in the Low Dorsal Region with Sharp Knuckle. Note how child supports weight of upper part of body on hands and arms.

restricted in all directions, but forward and backward bending of the head are more restricted than either rotation or side bending. There is never or rarely a knuckle seen with disease of the cervical spine, but there is often a distinct shortening of the neck. In the dorsal or thoracic region, the spinal rigidity is marked, a knuckle may be present, muscle spasm is present, and is a constant sign, due to the patient's attempt to keep the diseased and inflamed area quiet as motion causes pain. In the lumbar region, a knuckle may be present, but is rarely as large as those seen in the thoracic spine. Muscle spasm is present, guarding all motions. The lumbar spine shortens in the same

way as the cervical, giving the patient the appearance of a very short trunk and long legs.

There may also be some limitation of motion in one or both hips, and even the thighs may be held flexed at the hip due to the disease irritating the psoas and iliacus muscles which have their origin on the lumbar spine. The patient then may walk with thighs and knees flexed to guard the lumbar spine from jars and shocks. When lying flat on the back in lumbar Pott's disease, there may be seen a certain amount of lordosis or bending forward of the lumbar spine with the legs straight, due to the pull of the irritated psoas and iliacus muscles. Bending the hips and knees will allow the lumbar spine to become flat and straight.

No. 65.—Tuberculosis of Cervico-dorsal Spine Showing Marked Deformity and Shortening of Neck.

Turning the patient on the face and attempting to hyperextend the spine will demonstrate the presence of muscular spasm and rigidity. The normal spine will bend easily whereas the diseased spine is held stiff, and attempts to bend it cause pain.

In the cervical region, an abscess may develop due to the destructive process in the vertebræ. Abscesses in this region generally appear as retropharyngeal abscesses, and may be seen pointing or bulging in the posterior pharynx. They cause difficulty in swallowing, and if they rupture spontaneously may cause death by suffocation.

In the thoracic region, an abscess may form around the area of disease, and remain there quiescent, or enlarge and travel down the spine to appear in the flank, or in the iliac fossa as a

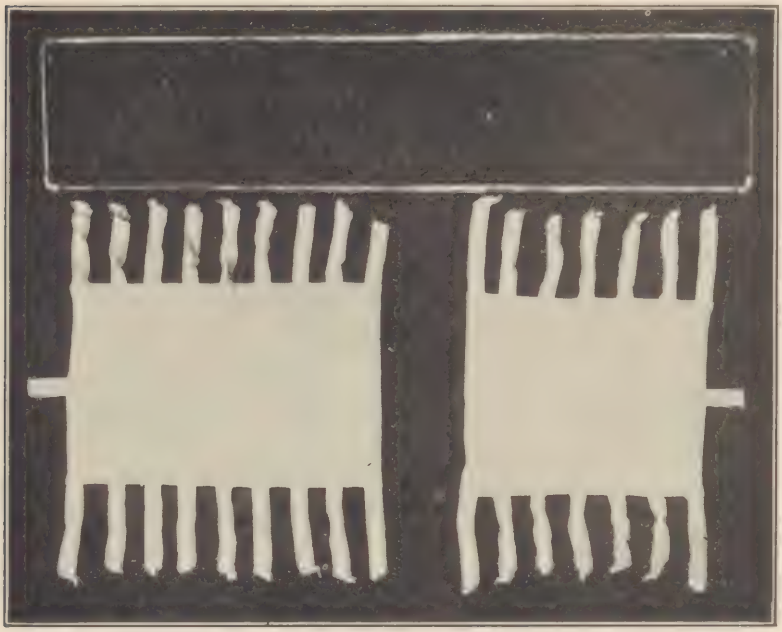
psoas abscess under the psoas and iliacus muscles. All these tubercular abscesses, unless they cause severe symptoms from pressure or are dangerous to life, are best left alone, and not opened. Under adequate fixation and recumbent treatment, they will generally absorb.

No. 66.—Old Healed Case of Tuberculosis of the Dorsal Spine with Large Kyphos.

The whole object of treatment is to protect the vertebral bodies from jar and superincumbent pressure until a cure is established. Therefore the superimposed weight must be removed from the part affected, and the spinal column so fixed as to secure rest and protection from motion to the vertebral bodies.

With the normal tendency of the weight of the head, shoulders and the thorax to bend the spine forward and so compress the vertebral bodies, and the intervertebral disks, no satisfactory ambulatory method of treatment, at least in the acute or subacute stages, has been devised which will insure a diminution in the activity of the disease, and a prevention of the increase in the kyphotic deformity. Braces are but levers, and not means of support, and however adequately fitted, never accomplish as much as theoretically they should, due to the fact that they are generally improperly applied and never worn tight enough. Therefore, some other and better method has to be provided for the satisfactory treatment of the acute cases, not only to prevent the increase in the extension of the disease, but to give comfort to the patient. This is best done by treatment in recumbency. Recumbency is after all the safest and best method, and is to be applied in one of the following ways: 1. Bradford frame—in dorsal and lumbar Pott's disease; 2. Head traction in cervical Pott's disease—Thomas collar; 3. Plaster shell; 4. Plaster jacket,

The method of handling is very important. The child should never be permitted to sit up, lie upon side, which twists the spine, or bend forward on side. The child may lie on its face. To turn the child, place arms above the head or down at sides, and turn as if in one piece. Later when the child gets up, the superimposed weight can be removed by head suspension and



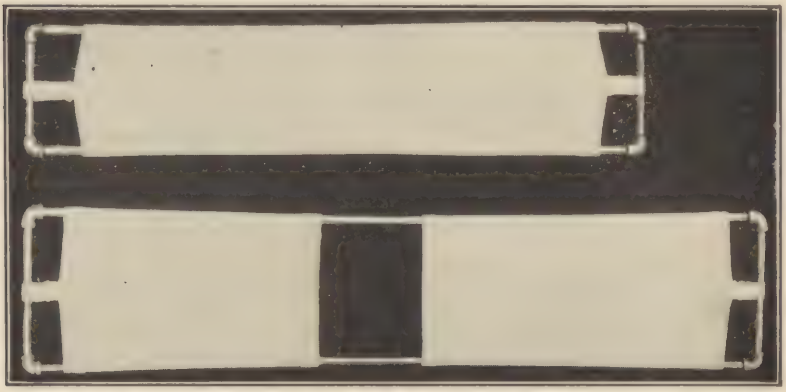
No. 67.—Uncovered Bradford Frame Showing Top and Bottom Canvas Spread Out Before Application.

fixation by brace or jacket. The principle of a brace is to straighten the spine backward by leverage, especially at the point of disease, and is not a means of direct support in the sense of removing superincumbent weight.

Anyone lying flat on a hard surface relieves the spine from weight bearing, but on a soft mattress or a spring bed which sags, this result is not obtained, and twisting or turning in bed may injure the diseased vertebræ. Therefore, individuals should be put to bed and secured on a bed frame. The flat bed frame (Bradford), the arched frame (Whitman), or a plaster

posterior molded to the back, are all suitable forms of apparatus for bed treatment.

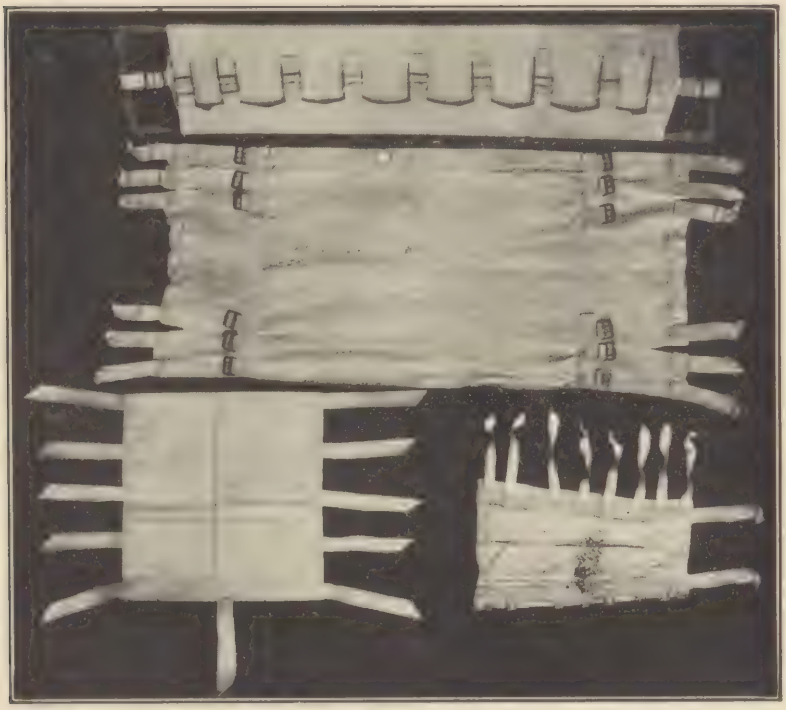
The flat bed frame of Bradford is made of 4 pieces of gas pipe (galvanized) screwed into angle joints called elbows. The size of the pipe varies with the weight of the individual and is usually ½-inch pipe. The frame is rectangular, and the length equals the length of the child plus 4 to 6 inches; width equals the width of the shoulders plus one inch, or better, the distance between the anterior superior spines. A frame too wide is worse than useless for fixation.



No. 68.—Bradford Frames. One for carrying child (entirely covered), and the other for bed use, with two-piece cover.

The covering should be stout canvas or duck almost as long as the frame and wide enough to overlap the sides, so that the edges may be laced to each other behind and pulled tight to prevent sagging and wrinkling. Except when the child is so small that he uses diapers, the covering should be in two pieces, leaving an uncovered space four inches wide for the buttocks, so that a bed-pan can be used without displacing the spine or hips. Tall, heavy children make the long sides bend together; to prevent this, a metal cross piece at the level of the middle of the thighs is used.

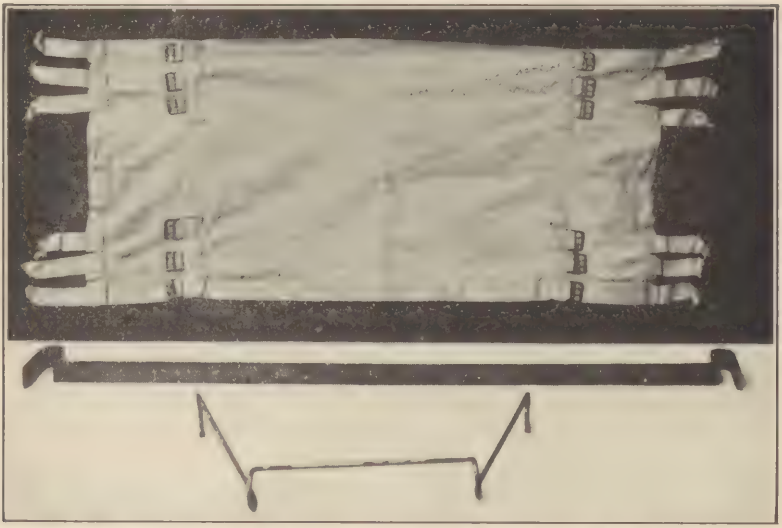
The covering is kept clean by laying a smoothly folded sheet over it, which may be changed. Where there is a projecting kyphos, it is raised by pads at either side of the spine, made



No. 69.—Bradford Frame Covered—from Behind. Cover spread out. Small frame cover. Stocking extension.

of folded pillow cases, felt, or folded sheets to prevent bed sores and to hyperextend the spine.

The child is secured to the frame by two crossed webbing straps passing over the shoulders, under the arms, under the frame and buckled. A towel, folded narrow and long, passing beneath the frame is pinned around the hips and another around the knees in the same way.



No. 70.—Frame Cover Spread Out with Two Iron Bar Supports for the Head and the Bottom of the Frame. The top support is the long iron one which goes across the bed and rests on the sides. The small iron one hangs from the foot of the bed, and the bottom of the frame is caught in the bent rung. These are for suspension of the frame above the mattress.

When psoas contraction demands that the legs be raised, pillows or folded sheets may be used to support them, but it is better to use a wooden inclined plane with a cord, pulley and weight, and an adhesive plaster extension as for hip disease. The traction should be applied as usual in the line of flexion deformity.

Care of Child on Frame.—*Clothing:* in bed; the undershirt and cotton night shirt should be split down the back, fastening only at the back of the neck. Going out-doors: a jacket may be put on in the same manner with a cap and mittens, but the

rest of the frame and the child can be wrapped in a shawl or blanket.

Feeding: even little children quickly learn to feed themselves with a spoon while lying flat on the back. A bed tray with four legs four and a half to five inches long is convenient. Drinking is accomplished with a tube or a "feeding duck," or a small teapot, the child sucking through the spout.

Bathing: the daily morning bath is given recumbent and every evening the back is rubbed with alcohol, and powdered. To do

No. 71.—Child on Bradford Frame. Note leg and pelvic straps, and webbing strap across chest.

this without injuring the spine, the frame with the child on it is moved to one side of the bed, the rest of the bed is covered with a blanket and a bath towel, the child relieved from fastenings is rolled into it by tipping the side of the frame up. After washing and drying the front and back separately, the child is rolled with its back against the frame which is tipped up on its side, and is firmly held there with one hand while the frame is let down flat with the other. In rolling a child who is not on its frame, the spine is little disturbed if the parent or nurse uses both hands simultaneously on the shoulder and on the ilium of the same side, turning the child as a whole.

The arched or stretcher frame of Whitman, constructed in

the same way, differs (1) in being narrower; and (2) in being bent under the deformity so that instead of lying flat, the child is arched on a double inclined plane with the head and feet low. The frame should be as wide as the distance between the glenoid cavities, the acetabula or what is the same thing, between the femoral arteries · its length exceeds the height of the child by 4 or 5 inches.

To prevent a restless child tipping over on its frame, it is a good plan to make the top and bottom of the frame as wide as a flat frame, but narrow under the child's body. The arching is done by bending the frame at the bedside.

The covering is the same as for a flat frame, in one piece and laced on tightly in the same way. The child is secured on the frame by an apron with straps similar to the one used for a back brace, the straps fastened to buckles sewed on the underside of the cover. A towel folded narrow and long secures the hips, and sometimes one is used for the knees.

Where there is a kyphotic prominence it may be protected from pressure by felt pads sewed to the cover. This is kept clean by a folded sheet as in the flat frame.

The frame must be bent only a little at first, and raised gradually a little each day till enough. The bend should be opposite the point of deformity.

Eating, bathing and clothing are the same as for a child on a flat frame.

The plaster bed consists of a posterior shell with an anterior lid, both of which are made of plaster, the ordinary five-inch bandages being used. The posterior shell is made by putting a stockinet shirt upon the patient, from top of head to below the knees. A hammock is swung from a frame, and the patient is placed face down with the arms at right angles to the body, and the apex of the kyphos is marked with an indelible pencil, as well as an area about the buttocks to be cut out later for nursing care. The child may also be face down on a table with the back and thighs raised on pillows to obtain hyperextension of the back. The head, spine and legs are held in the same straight line, and the first plaster bandage is applied in continuous turns from the knees to the axillæ. The plaster

is then continued over the shoulders, neck and head by half turns, which should extend well out over each shoulder and include each side of the head. Successive half-turns should then be applied to the back and thighs, extending to the mid-

No. 72.—Child in Posterior Plaster Shell.

axillary line on each side, and the last plaster should make continuous turns as did the first. The posterior shell should not be more than one-half inch in thickness, and the neck should receive special attention, since it is most likely to be the weakest

No. 73.—Same Child Lying in Lid or Anterior Portion of Shell.

point. The shell is removed by making a longitudinal cut on the ventral surface and spreading the sides well apart. Immediately after removal the edges of the shell should be trimmed, and a circular opening of ample size cut out for the use of the bed pan. It is then dried, lined with felt, and covered with stockinet.

The anterior shell is made in the same way, only the child

lies on the back in the previously made posterior shell, and the anterior surface of the body is covered with a thin sheet of sheet wadding extending from the chin to below the knees. Plaster bandages are then applied and carefully moulded, especially about the chin and between the legs, so as to get an accurate fit. Before the child is turned out of the shell, the anterior half or lid is strapped on, and the child turned on its face lying on the lid. The posterior portion is then lifted off, and the child's back bathed and the necessary nursing care given.

Traction to head is useful in cervical, high dorsal, and lumbar Pott's disease (1) during paraplegia; (2) to correct torticollis;

No. 74.—Child on Bradford Frame with Head Extension for Cervical Pott's Disease.

(3) to relieve neuralgia and referred pains in cervical disease; (4) to overcome muscle spasm, and (5) to correct thigh flexion.

It is applied in cervical Pott's disease by means of a simple webbing strap and buckle covered with soft material, like flannelette, encircling the forehead and occiput; from above each ear a strap at right angles buckles to a wooden bar or spreader a little wider than the biparietal diameter. From the center of this spreader, a cord passes over a pulley at the head of the bed, four inches above the mattress, to a weight of three pounds or less for a child. The counter pull is obtained (1) by raising the head of the bed; or (2) by a downward pull from a waist band or adhesive plaster extensions. A sand bag on either side

of the head often helps greatly. In lumbar Pott's disease, a pull can also be applied to the legs.

Traction by an adhesive plaster extension on an inclined plane in the line of deformity is useful to reduce hip flexion from psoas contraction. The leg should be lowered a little each day as the flexion is overcome; five to twelve pounds are used according to the size of the child.

No. 75.—Child with Thomas Collar for Cervical Pott's Disease.

The Thomas collar originally was made of soft leather sewed into a tubular form, and stuffed with sawdust, making a thick cushion for the neck, fastening at the back with strap and buckle. It has been much employed for cervical caries with excellent results, but is useless for cervico-dorsal or high dorsal cases unless in combination with a brace or jacket. A much smaller collar is often used now, made of cardboard cut to fit the neck, and extending from the chin to the sternal notch, from the mastoids to the root of the neck, and from the occiput to the spine of

the scapula on each side. This is wound and padded with oakum and cotton bandages, and tied together at the back of the neck. Much better supports of a similar character may be made of celluloid, or leather stiffened with celluloid modeled upon a cast of the chin, occiput, neck and shoulders. In order to give a true fixation, it should extend on the chest as low as the xiphoid cartilage. It may be made to lace together over the shoulder on either side, and to take a bearing on the sides of the chest under the axillæ.

Plaster Jacket.—This type of support may be used during the subacute and ambulatory stages of the disease, and offers better fixation and support than a steel brace. It may be applied either with the body held by the head traction apparatus in the erect position, or with the child lying on the back or face. Whichever method gives the best bodily position and the best leverage on the diseased area is the one to be used.

The child is fitted with an undershirt, and the bony prominences, such as the anterior superior spines, are covered with thin felt to prevent chafing. The kyphos may be protected by a piece of felt split in the middle and spread so as to allow the spinous process to stick through, or small pieces of felt may be placed on either side of the kyphos to make pressure over the transverse processes, and keep direct pressure off the tip of the spinous process, and so prevent pressure sores. A folded piece of sheet wadding may be placed over the shirt, over the abdomen which is to be removed as soon as the jacket is dry. This is called a "dinner pad," and is to prevent too much compression of the abdomen. In older children, felt or sheet wadding is placed over the chest to prevent pressure spots, and in girls to protect the breasts from too much pressure.

These jackets to be satisfactory should fit snugly about all bony prominences, and should hold the spine in moderate hyperextension. After hardening, it is to be trimmed so as to allow for a comfortable sitting position. It should not be too high under the arm as a "crutch paralysis" may develop in the hands and arms from too great pressure in the axilla.

The Calot jacket is made in suspension and includes the neck and shoulders, giving support to the chin and occiput, and hav-

ing a window over the kyphos through which it is padded by felt being inserted so as to decrease the deformity. These jackets are more useful in the cases where the disease affects the vertebræ above the 8th dorsal region. Jackets should be watched for pressure spots, as children are prone to drop crumbs, buttons, coins, and in fact anything they can get their hands

No. 76.—Calot Jacket for Cervical Pott's Disease.

on under the jacket. These all may cause pressure sores, and are to be watched for. Jackets may be worn for indefinite periods so long as they do not become too tight, broken or dirty.

Pain, weakness, loss of use of legs, increased reflexes all point to inefficiency of support, and are indications that the jacket is not doing its work, and that recumbency in a shell is advisable. Frequent inspection of a child in a jacket is essential.

When it is necessary for a child with Pott's disease to get up,

he must be supported, and the spine fixed so firmly that no harm will accrue. Plaster jackets are available and for many children are preferred to steel braces in the beginning of ambulatory treatment. Plaster jackets may be applied either upright or recumbent.

No. 77.—Back Brace for Pott's Disease with Head Support.

A support for the head is needed in all cases involving the upper half of the dorsal spine or the cervical spine. These may be fashioned in plaster of Paris by extending the jacket upward after it is complete in other respects, so as to form a collar which will give effective support to the chin, sides of the neck and occiput.

The child with a jacket on for the first time out of bed must not be overtired; sitting up in bed, or in a chair, for a few hours is enough for the first day. The next, he may run around a little, but if he has long been recumbent he must be helped. Little by little play is resumed, but for a long period in the middle of the day he must lie down. A child who wants to lie down should never be denied. Parents must be instructed to guard the lower portions of the jacket from soiling, and to keep the plaster dry when bathing the child; also to keep him from dropping pennies and beads inside of it. The chief objection to these jackets is their uncleanliness. It is well for parents to be on the constant watch against vermin. Any irritation of the skin or abrasion rubbed upon by the jacket may cause suppuration and a foul odor. This odor must be watched for by the parents who should bring in the child at once for a new

jacket. Jackets which are properly padded and effectively modeled on the child should not excoriate, but the accidental occurrence of vermin may necessitate removal, notwithstanding the fact that children do uniformly better if they wear each jacket a very long time, as the spine left undisturbed for long periods has a better chance to cicatrize.

Removable jackets and braces are often ineffective because careless and ignorant parents either remove or misuse them. The duration of an effective jacket may be 15 to 16 months; the whole jacket treatment may take 4 or 5 years. Removable jackets are more cleanly but give a far less efficient support.

No. 78.—Tuberculosis of Spine with Large Psoas Abscess.

Permanent plaster jackets when they begin to soften without being ineffective may be strengthened by adding more plaster bandage.

By a steel brace an efficient fixation can be obtained for the spine as with the jacket, but the construction, the application, and the nice fitting must be done by the surgeon himself, and as the child grows, constant readjustments must be done by him.

The daily application of a steel brace requires great care and attention on the part of the parents, and only where that can be assured should it be employed. Moreover, the brace should be watched by the surgeon at least once a month for any slight error which may develop in accuracy of fit, or a relapse may ensue.

Tuberculosis of the Hip.—This is a common condition in childhood, and next to tuberculosis of the spine, is probably the

most common type of tuberculosis that we see affecting the joints.

The disease usually makes its appearance at the upper end of the femur near the epiphyseal line, and as shown in x-rays may primarily involve the neck of the femur at or below the epiphyseal line, as well as the head of the femur, or may involve primarily the acetabulum. This latter occurrence, however, is

No. 79.—X-ray of Case of Tuberculosis of the Hip. Note destruction of head of bone and acetabulum.

not as frequent as involvement of the head and neck. The disease extends gradually until it reaches the hip joint, where it breaks through all the joint structures and destroys the cartilage, synovial membrane, etc. Abscesses are very apt to develop as a result of this increasing destruction, and these abscesses may appear in front or behind the hip joint, or on the outer side of the leg below the trochanter. Sometimes an abscess entirely separates the head of the femur which then acts as a sequestrum or a foreign body. When the acetabulum has become diseased,

an enlargement of it generally takes place as a result of the intra-articular pressure secondary to muscle pull about the hip, and the upper edge of the acetabulum is therefore eroded away by the upward pressure of the femoral neck. This condition of the acetabulum is known as a "wandering or migrating acetabulum." This condition naturally results in a short leg on the affected side.

The beginning of this disease is often gradual and insidious, but it may be at times so abrupt as to suggest a traumatic origin, and may suggest a fracture of the hip following a fall. The patient is rather apt to be out of condition. There is oftentimes a limp for which the patient is first brought to the hospital. This limp is most marked as a rule in the morning, and may vary somewhat from day to day. Night cries in the early and acute stages are frequent. These night cries come on while the child is asleep, and are the result of primary relaxation of the muscles about the hip. When the muscles are relaxed and the hip held in an unguarded state by the patient, the head of the femur presses against the acetabulum. This causes pain, and the child wakes up with a sharp cry. After a while the child will quiet down and go to sleep. As the condition continues, the leg is held stiff at the hip, with the thigh held flexed on the abdomen, outwardly rotated and abducted. Motion in the hip joint in the acute stage is impossible, and attempts to move the leg cause a great deal of pain. If the patient can bear weight on the leg, it is done with the toes on the ground, putting the weight on the ball of the foot and not on the heel. On inspection of the child, it is noticed that he lies on the table with the leg flexed, abducted and outwardly rotated. On palpation about the hip oftentimes there can be felt definite thickening about the hip joint, in front of the joint as well as behind. There is usually a good deal of muscular atrophy of the leg. Muscle spasm is very important, and is a constant factor. This muscle spasm which guards the hip against motion is nature's way of preventing pain and discomfort, and is a constant sign of irritation in the hip joint. In the early stages, the pain in the knee is oftentimes the only thing complained of, and many children are seen by physicians for pain in the knee when the

condition is really due to some inflammatory condition in the hip. The knee on examination will be found negative. The pain in the knee is due to the fact that the obturator nerve runs over the capsule of the hip joint and supplies the inner part of the knee joint. Irritation in the hip joint stimulates this nerve, and pain therefore is often referred to the inner side of the knee. Any child complaining of pain in the knee should invariably have the hip examined.

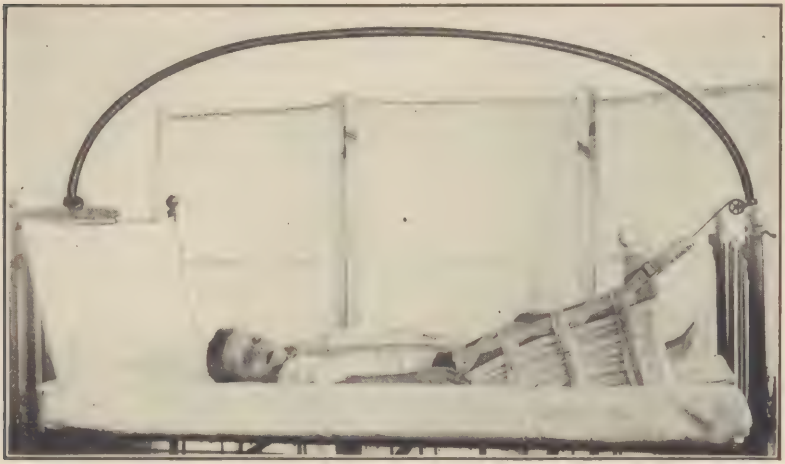
The object of treatment is to remove all bruising of the joint by jar or by motion, and give the part entire rest. This is done by fixation, traction and protection. Fixation is accomplished by putting the child in a recumbent position on a Bradford frame. Traction is accomplished by putting an adhesive extension on the leg on the affected side. As we have already seen the muscles of the thigh and leg are in a constant spastic state. Our object is to tire the muscles so that as they tire they will relax and allow the leg to resume its normal position.

The leg is put up in the line of deformity and as much weight as possible is used for traction. As a general guide, we can say that for a child two years old, we put on five or six pounds, for a child seven years old, eight or nine pounds. More than this may be ordered by the doctor.

What is meant by line of deformity? Supposing a child comes in with his leg everted and abducted and the knee flexed. We would treat the abduction first. The leg would be put in abduction to the degree that would bring the two anterior superior spines even and parallel with the foot of the bed. We would then treat the flexion. Elevate the leg at an angle until the back is flat on the bed. (This corrects lordosis which is an abnormal concave curve in the lumbar region due to muscular spasm). Let the leg down a little every day but do not drop it too quickly. The angle of elevation may be secured by either putting the leg on an inclined plane or on pads. If pads are used they must be adjusted so that there are no abrupt falls, and they must go the whole length of the leg from the fold of the buttocks down to the tendo-achillis. These pads must be fastened with three narrow straps to the leg.

If night cries and sensitiveness continue after the extension

has been applied in the line of deformity, lateral traction may be put on. When counter traction is needed, the foot of the



No. 80.—Tuberculosis of the Hip. Note overhead crane and padding under leg for flexion deformity.

bed is elevated to allow the body to pull against the weight on the end of the leg. This can also be accomplished by putting

No. 81.—Child in Frame in Bed for Hip Disease in Traction. Note padding holding leg in line of deformity. Note bar at foot of bed to keep clothing off leg.

a perineal strap around the well groin and attaching it to the head of the bed or the top of the frame. A perineal strap or raising the foot of the bed will prevent the weight of the extension from pulling the child down in the bed so far that the foot

spreader rests against the pulley. A toe spreader is always used to hold the foot at right angles and to prevent toe drop.

In putting the hip on traction, two nurses are needed: One to exert constant traction by holding the foot at the ankle, the other to apply the extension. When once traction is started, never let up on it. In transportation, constant traction may be made by fastening the toe spreader with pins to the frame. All jar and motion should be avoided. One should never lean or sit on the bed. When moving the frame, it should be moved very carefully and easily.

The skin should be watched closely for excoriations, discolorations and edema. The child with a tubercular hip should be turned off of the frame twice a day, and have his back rubbed. He should be turned on the affected side, traction being kept up on the leg as he is turned.

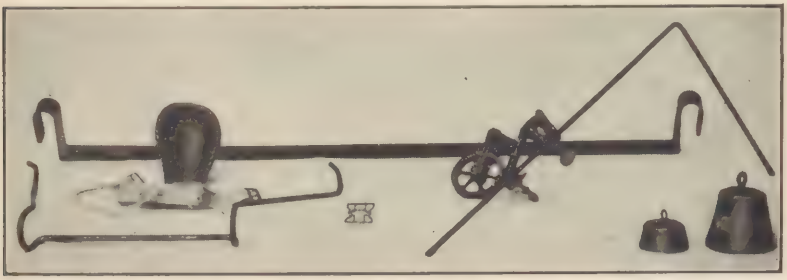
Care should be taken that the opening in the frame cover is not too large, four inches generally being sufficient, but this all depends on the size of the child.

The acute stage of tuberculous hip disease almost always demands bed treatment, to give both fixation and traction, in order to prevent movements in the hip joint and pressure from the spasm of the strong muscles surrounding that joint. The rare exceptions occur in those whose focus of ostitis is not close to the joint and who, therefore, do not have much spasm. These may be allowed to walk at once with a traction splint, crutches, and a high sole on the well foot, but may require bed treatment later.

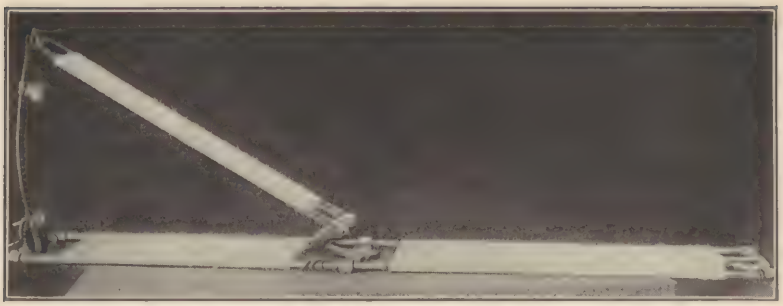
The child is secured on his back on the Bradford frame in the same way as for Pott's disease, except that only the unaffected knee is fastened to the frame by a towel. By means of adhesive plaster extensions, a spreader, cord and pulley traction is then made in the direction of the leg's axis. The pulley is placed so that the pull is in the line of the leg when the pelvis is perfectly square on the frame; that is, for permanent flexion, the pulley is raised, for adduction, moved in, and for abduction, moved out; and if raised, the leg is to be supported on folded sheets or on an inclined plane. When possible, there should be a sand bag on either side of the leg to

No. 82.—Stocking Extension and Sticking Plaster Extension. Stocking extension.—Material: unbleached muslin double thickness. Narrow webbing. Wide webbing (for attaching toe piece). Small buckles. Measurements: Width at top—circumference of thigh. Width at bottom—circumference of ankle. Length—1 inch above malleolus almost to groin.

No. 83.—Foot Rest, Weights, Pulley, and Rod to Keep Clothes Off Patient's Leg. Apparatus used for traction.

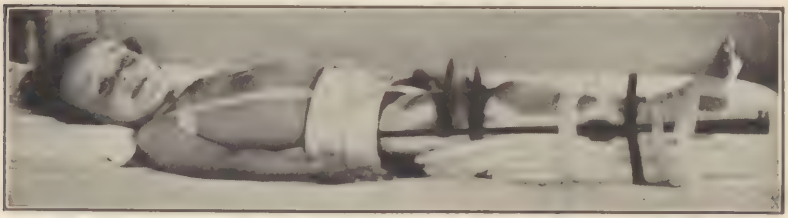


No. 84.—Apparatus for Traction, and Iron Supports for Frame in Bed.



No. 85.—Inclined Plane Attached to Bradford Frame.

No. 86.—Tuberculosis of the Hip. Traction on inclined plane incorporated with Bradford frame.



No. 87.—Tuberculosis of the Hip. In bed on frame with Bradford abduction splint on.

steady it; and a "cradle" to keep the weight of the bed clothes off the foot, the axis of which should be kept nearly vertical. The foot of the bed should be elevated to give the counter pull.

Efficient recumbent treatment is also possible in hip disease by the application of a plaster of Paris bandage enclosing the trunk, the affected limb, the pelvis, and upper part of the unaffected thigh. This method limits the amount of muscular spasm, crowding the head of the femur into the acetabulum by steadying the joint, but it does not distract or separate the joint surfaces, and is therefore neither as efficient or as comfortable as the use of the frame and traction splint properly adjusted.

Adhesive plaster extensions are made in pairs, and applied in several ways, but the following method has proved most useful: to the end of a strip of adhesive plaster an inch wide (any unirritating adhesive plaster like Z. O. plaster) is sewed a 6-inch strip of webbing, and where the two join together, a second strip of adhesive plaster is sewed on to make an angle of 45 degrees with the first piece. The adhesive plaster strips which continue the line of the webbing are applied from just below the perineum to a hand's breadth above the internal malleolus, and from the trochanter major to the same distance above the external one. The two oblique adhesive strips are then applied so as to cross each other as they ascend, first in front over the shin; next, behind over the upper part of the calf of the leg; in front again, just above the knee; again behind the thigh, covering the ends of the straight pieces of adhesive as they take a final circle around the top of the thigh. They must be applied firmly and smoothly and should be covered with a muslin or gauze bandage for twenty-four hours, to make them stick tight. These extensions need to be changed only when they become so loosened that they are inefficient. Unless applied evenly and smoothly the edges will cut, and many forms of adhesive plaster are irritating to the delicate skin of the child. To remove the adhesive plaster, moisten with alcohol, benzine, water, carbona, or ether.

The amount of weight for traction must, of course, vary with the age of the child and the condition of the hip. From five to fifteen pounds or more may be used, and as much should be

applied as can be borne without discomfort. With heavier weights, the adhesive extensions need to be more frequently renewed. The extension should be sufficiently heavy to stop night cries.

No. 88.—Tuberculosis of the Hip. Bradford abduction splint from rear.

No. 89.—Tuberculosis of the Hip. Bradford abduction splint from side.

In many cases, where acute symptoms and night cries persist under good traction, lateral traction may be of benefit. This is applied by hanging a weight over the side of the bed attached to a strap 2 inches broad passed loosely around the upper part of the thigh. Usually five to ten pounds is employed, and sand bags should be placed to steady the thigh below the strap, and at the pelvis above it. In lateral traction, resistance to the pull

is given by another band running around the ilium on the diseased side, and tied or weighted on the opposite side of the bed.

The care of the child on the frame is essentially the same for hip disease as for Pott's disease, only still greater care has to be exercised not to disturb the diseased hip. Traction is made upon the leg when the patient is turned, and the hip joint should not be moved during the process. Traction without a bed frame is ineffective on account of sagging.

In regard to duration of bed treatment, as cases vary, good judgment is needed to determine the proper period for each, but unless for good reason it should always be as short as possible. The recurrence of acute symptoms may necessitate a return to bed treatment later on, and it is often necessitated by a fall, even after apparent cure.

Abscesses sometimes absorb under recumbent treatment, but they may enlarge and even break. They may also be aspirated or incised, and drained under strictly aseptic precautions.

Tuberculosis of the Knee Joint.—Tuberculosis of the knee joint in children occurs next in frequency to tuberculosis of the spine and hip joint, and is followed in frequency of occurrence by disease of the ankle joint. There is a greater frequency of the occurrence of joint disease in the lower extremities as contrasted with that in the upper ones.

In tuberculosis of the knee joint, it has been determined that there is a marked predominance of the male sex as compared with the female. It is essentially a disease of early life, and the greatest incidence of the disease is between the ages of two and three years.

Thirty per cent of the cases give a history of trauma, but of how much significance this may be in the etiology of tuberculosis of the knee is a disputed question, for it has been stated that "the relation of trauma to bone tuberculosis must, sooner or later, be established as having no existence in the etiology, or in the beginning of the process." The primary cause of bone tuberculosis is essentially infection by the bacillus of tuberculosis; and any condition which lowers the vitality, and therefore the resistance of the patient, must be considered contributory. Fractures and other severe traumatisms do not cause bone

tuberculosis in animal experimentation or in human beings, and it is inconceivable that lesser injuries should do what greater injuries fail to do.

On the other hand there is the theory that following a mild injury, there is an inflammatory exudate which offers the tubercle bacillus a favorable field for growth, if it is already present in the body, while if the injury is severe, the reparative processes are so active that the bacillus is destroyed even if it does obtain access to the injured part.

Upon the basis of clinical experience, the majority of surgeons at the present time have reached the conclusion that the influence of trauma is not concerned with the development of bone and joint tuberculosis, but with an effect upon bones and joints that were previously diseased with tuberculosis. In view of these conclusions and the results of much experimental and clinical evidence, we must conclude that trauma is only an incidence to the development of the disease in many cases, but may be a predisposing factor in some.

Exposure to infection from tuberculosis must be taken into consideration in connection with the etiology of these cases. Many cases give a history of tuberculosis in the family, and there is little doubt that there is a family history of tuberculosis in many of the cases. On the other hand, there is the general consensus of opinion that surgical tuberculosis is usually of the bovine type, that it probably comes from milk, and is the type which affects the bones, glands, peritoneum, ear, and genitourinary tract.

In any group of cases suffering from surgical tuberculosis, there is always a certain percentage who are so unfortunate as to have more than one joint affected. In contrast to other groups of cases, it will be noted that those having ankle disease show a large percentage of involvement of other joints.

There is considerable diversity of opinion among various authorities whether the location of the primary focus in tuberculosis of the knee is synovial or osteal. Nichols, from an examination of 120 tuberculous joints of adults and children after amputation, excision or autopsy, discovered primary bone foci in every instance. He believes primary synovial disease

to be very uncommon. From a clinical standpoint, however, one recognizes two distinct types of tuberculous disease—one beginning as a chronic synovitis; and the usual class of cases, where the symptoms of pain, spasm and deformity are acute, and seem to indicate bone disease. As a rule the bony type seems to predominate in children, and the synovial type in adults.

The disease may start as a bony focus in the femur, tibia, patella, or fibula. The original tubercle enlarges by coalescence with others, and as the areas enlarge they form in the marrow of the bone irregular caseous masses. Because of this condition some authors believe that the condition should be called a tuberculous myelitis. These areas may soften and become abscesses.

Symptoms.—

1. Intermittent lameness (or it may be constant).
2. General enlargement of the knee joint.
3. Stiffness and pain when using the limb.
4. Local tenderness.
5. Muscular stiffness.
6. Heat over the joint.
7. Knee loses contour.
8. Patella seems raised by a solid mass.
9. Knee is boggy, later assumes a spindle shape.
10. The affected limb is likely to be longer than the well, owing to congestion of the epiphysis.
11. Pain or jarring the limb is common.
12. Night cries occur.

The disease generally begins in the spongy tissue of the epiphysis, near the junction of the epiphysis and the diaphysis, and generally in the region of the internal condyle rather than the external. This point has been so commonly noted in our observations of histories and cases that we feel it is almost pathognomonic of the disease to have an enlargement of the internal condyle, plus of course the other usual symptoms. It may result in swelling of the peri-articular tissues and abscess formation, with distortion of the limb. Finally, flexion and subluxation with fibrous or bony ankylosis occurs. Extensive suppuration is a possible result ending in general toxemia.

Sir Harold Stiles of Edinburgh states that as a result of his

experience the most common situation to meet with a primary osseous focus is in the metaphysis, and not in the epiphysis He believes that modern text books are wrong in teaching that primary tuberculosis of the long bones usually starts in the epiphysis. He says that this may be the case in adults, but it is certainly not so in children. He also states that primary synovial disease is more frequently met with in the knee than in any other joint. He states that the localization of the disease in the bones is accounted for by the distribution of the intraosseal vessels, and that in children the disease is more frequently met with in the growing ends of the diaphysis (the metaphysis) than in the epiphysis. The joints which are most often and earliest involved secondary to an osseous focus are those which possess small epiphyses. In the rare instances in which the disease begins in an epiphysis, it does so more especially in those which are relatively larger, and which begin to ossify early, such as the knee.

No. 90.—Tubercular Knee with Large Abscess.

The most common and almost universal symptom is enlargement or swelling, and was probably the cause of the condition being called "tumor albus." The four most noticeable symptoms, as is true we believe of all cases, are (1) swelling, almost universal, generally bony, and often shown by an increase in the actual bony measurements of the condyles as contrasted with the well leg, and generally most marked in the region of the internal condyle, resulting in their actual widening. (2) With the swelling, which is generally both intra-articular and peri-articular, there is of course limitation of motion, as a result of muscular spasm, and distension of the joint

capsule. (3) Permanent flexion with outward rotation and subluxation of the tibia on the femur is a common symptom, and is

No. 91.—Old Tubercular Knee with Marked Flexion Deformity.

due to muscle spasm. Whether the deformity is the result of the ham-string muscles pulling at greater advantage, or a reflex protection action, we cannot determine. It is at first only a true flexion of the joint, as contrasted with the later development of the subluxation to a greater or less degree. (4) Heat is a most important symptom, and while persisting, means activity of the process, and indicates to a great extent the necessity of further protective treatment.

No. 92.—Old Tubercular Knee. Flexion and subluxation. Multiple sinuses.

There is generally a certain amount of knock knee apparent, due to the swelling and enlargement of the internal condyle. Abscesses and sinuses are self-evident. Fluid in the knee joint in tuberculosis is not usual, unless it is pus. The swelling as a rule is due not to fluid, but to thickened, vascular synovial membrane, and infiltrated soft parts generally, and presents a rather hard, boggy feeling, quite in contrast with

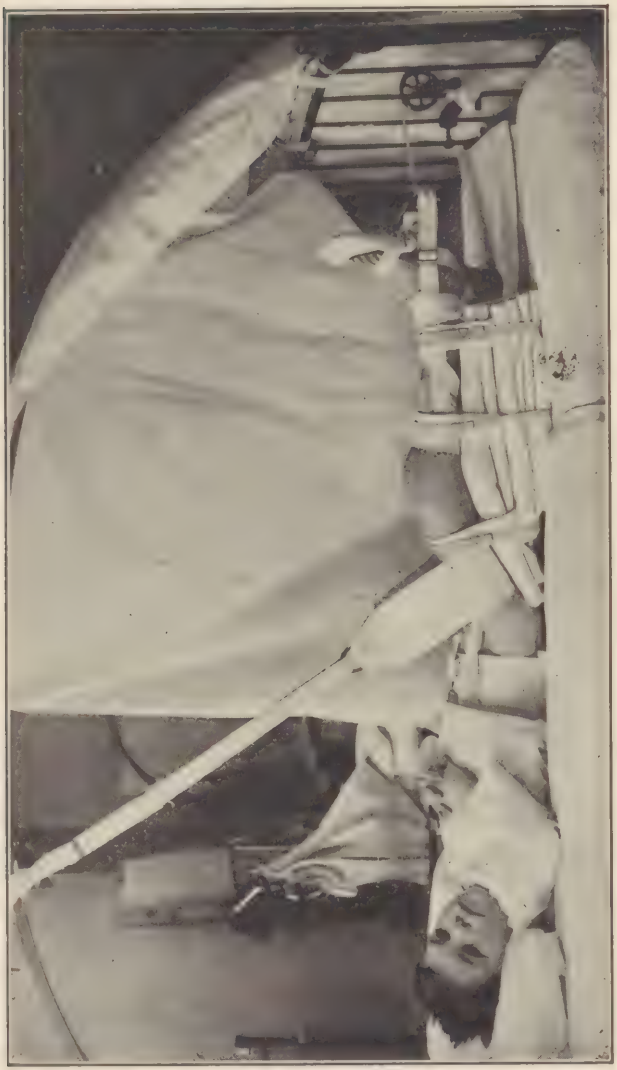
fluid in the joint, as seen in acute synovitis, where the patella floats and can be depressed with a distinct click.

A further discussion of these signs is unnecessary. The affected limb when straight is nearly always longer in the first two years, usually longer in the second two years, and usually markedly shorter after seven years' duration, if the period of growth is past. The affected femur is nearly always longer in the first four years, and the lengthening of the leg is mainly due to lengthening of the femur. This lengthening of the femur may often be detected within half a year of the onset. The tibiæ are usually equal in length in the earlier stages, afterwards the affected tibia may be slightly longer for a time, but is more often shorter in the first two years. This shortening increases in the older cases, and after subsidence of the inflammation. If the limbs are of equal length some years after the onset of the disease, the femur of the affected side will be found longer, the tibia shorter than its mate. The final result is often a shortening of from one to several inches.

Certain cases develop abscesses. These cases are also usually accompanied by other acute symptoms, as flexion, spasm and heat, and require drainage or other operative interference. Late abscesses may be due not so much to the acuteness of the process in the joint, as to the effect of the accumulation of the tuberculous detritus and fluid breaking through the joint capsule, and burrowing about in the muscles and fascia in the region of the joint.

Treatment.—

1. Must be thorough and efficient.
2. Fixation and protection are most important.
   Fixation as long as there is any activity.
   Protection until epiphysis is normal in strength.
3. In the acute stage keep patient in bed with traction.
4. For the ambulatory treatment have leg in plaster from pelvis to and including the foot.
5. Thomas knee splint may be used with a thick sole on the shoe of the well limb, in order that the affected limb may swing clear. Crutches are necessary.



No. 93.—Bed Traction for Tuberculosis of the Knee. Note padding under knee, perineal straps, and counter traction to overhead crane above knee.

6. Excision of knee joint used only when conservative treatment fails.

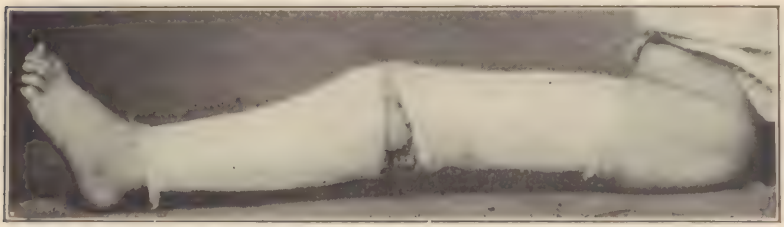
Treatment of tuberculosis of the knee must be thorough and efficient from a mechanical point of view. Fixation and protection from weight bearing and motion are most important, and these are obtained by means of fixation in a plaster cast or a long spica extending from the lower ribs to the toes. Recumbency in bed in the acute stages on a Bradford frame, with traction on the lower leg, is essential to relieve pain and spasm and induce fixation.

After the acute symptoms have subsided, the child may be allowed up with either a short or long cast on, using crutches and a high sole on the well leg to allow the affected leg an opportunity to swing clear. With a short cast, that is, one extending from the groin to the ankle, added protection by means of a Thomas splint is generally wise. Weight may be put on this splint without harm to the knee, as the splint is two inches longer than the leg, and the thrust is carried on the ring of the splint at the top, and so transferred to the ischium.

If deformities exist, such as flexion and subluxation of the knee, they are to be corrected either by traction in bed on a Bradford frame, or by the application of a cast, which extends from the groin to the ankle. This cast is applied with the leg as straight as possible without the use of force. When it is dry and hard, it is cut transversely behind the knee about two-thirds of the way around. In this cut are then forced narrow wooden strips, like throat sticks, increasing one or more a day, until the leg is straightened by this wedging process. Care should be taken to pad well over the patella and avoid pressure sores.

Following straightening of the leg, a new cast is applied, which is worn with a Thomas splint for further protection. This method of treatment is to be maintained with freedom from use and weight bearing for a period of a year. In children, two to three years, protection is necessary, but then one is not sure of a cure, for trauma, strain, or a sudden wrench of the then unprotected knee may light the whole process up again.

In adults, early excision of the knee is to be done as the best



No. 94.—Tuberculosis of the Knee. Plaster cast spread and wedged from behind with throat sticks for correction of knee flexion deformity.

No. 95.—Tubercular Knee. Showing front of long plaster spica for adequate fixation of the knee.

No. 96.—Tubercular Knee. Showing back of long plaster spica for adequate fixation of the knee.

No. 97. — Thomas Splint Assembled, Ready for Application.

method of producing a cure, and the result is of course a stiff knee in slight flexion, as the position of least disability.

Bed Treatment.—The care of the child does not differ materially from that for hip disease. The reduction of flexion and subluxation by weights and pulleys in bed is accomplished by securing the child on a Bradford frame and fastening to the head and foot of the bed a straight or curved rod over the affected leg, to which pulleys are attached. A broad cloth band, encircling the thigh just above the popliteal space, and attached to a pulley and weight on the rod near the head of the bed, serves to keep the hip flexed so that the lower leg will be horizontal; a second pulley attached to the opposite end of the overhead rod carries a weight, cord and spreader fastened to extensions of adhesive plaster on the leg below the knee, while a broad cloth band passing under the head of the tibia is

No. 98.—Thomas Splint on Leg. Note strap over opposite shoulder.

attached to a third pulley weight vertically over the knee, lifting the head of the tibia forward upon the condyles of the femur. When properly applied, this apparatus is comfortable and speedily effective if the flexion deformity be wholly due to muscular spasm. As day by day the line of pull is changed, the limb gradually straightens, and a time is reached when the leg may be supported on a folded sheet and longitudinal traction only be employed. It is then ready for immobilization in a straight position in a plaster cast.

During the early stages of tuberculous knee joint disease, there may be few acute symptoms, bed treatment may often be dispensed with, and the child may be safely permitted to wear a plaster of Paris cast. The parents, however, must see that no weight bearing on the affected leg is allowed. The method of applying the Thomas splint is as follows: it is applied by slipping the ring of the splint over the foot and up the leg. The padded ring of the splint should fit snugly around the perineum and groin. The uprights along the inner and outer aspects of the leg end in a foot plate two inches below the sole of the boot. A long webbing strap and buckle are fastened to the back part of the padded ring, passing over the shoulder on the opposite side, and buckling near the front of the ring to keep the splint from slipping off when the leg is lifted from the ground. After this is fastened, the leathers are laced together over the thigh and calf. If there is no plaster bandage, a leather knee cap is firmly strapped in place. Owing to the rigid perineal crutch afforded by the ring of this Thomas splint, the principal weight bearing comes on the ischium and pubes, and the skin on the side of the perineum must be toughened by bathing two or three times a day in alcohol and powdering. Ordinary yellow soap rubbed on the leather ring will often prevent sores. A high sole must be provided to compensate for the extra length of the splint below the sole of the boot on the opposite leg, generally about 2 inches to 2½ inches high. Crutches are necessary in learning to walk but after a while may be discarded.

Tuberculosis of the Ankle Joint and Tarsus.—

I. Symptoms:

1. Pain and sensitiveness in motion.
2. Swelling and heat.
3. Lameness comes early.
4. The foot usually assumes a position with the toes pointing downward.
5. In chronic cases the foot is slightly everted.

II. Treatment:

1. Rest.
2. Protection from jar by fixation of joints.
3. Thomas knee splint often used.
4. Attention to hygiene and food.

III. Prognosis:

1. Ankylosis sometimes occurs.
2. In adults amputation.

Tuberculosis of the ankle joint and the bones of the foot is much more frequent in children than in adults, and follows next in frequency tuberculous disease of the spine, hip or knee. Affecting bones and joints which have to bear weight, its treatment and course are necessarily much more difficult and protracted than in joints such as the shoulder and elbow. Also, owing to the superficial position of the bones of the foot, abscess formation is more noticeable and subsequent operation usually more often indicated.

Generally, there are a few more boys affected than girls, probably due to their greater exposure to trauma. A tubercular family history is important, and about a fourth of the cases have other joints involved. Also it should be noted that a long time usually elapses from the onset of the disease, that is, when the parents first noticed that there was something wrong with the foot, before bringing the child to the hospital for treatment. This is often due to lack of responsibility on the part of the parents, and again to mistaken diagnosis on the part of the family physician, who believes the condition to be a chronic sprain or a rheumatic condition. It also points forcibly to the insidious and slow nature of the process. The average age of occurrence is about 4½ years.

The onset is usually slow in these cases, and may follow an injury, such as a blow or a sprain. Any sprain which does not

clear up promptly under the usual measures should make one most suspicious of some other process going on. Swelling follows about the part involved. If the disease is in the astragalus or the lower end of the tibia or fibula, there is swelling about the ankle joint, often to such an extent that the outlines of the malleoli are obliterated. Where the tarsal or metatarsal bones are involved, the swelling is more defined and localized over that area.

Limp and muscle spasm are noticeable, especially in disease of the ankle joint. Lameness is an early symptom. Motion is limited, especially in plantar and dorsal flexion, and the foot assumes a position with the foot pointing downward. Where the tarsal bones are involved, there is usually very little spasm, and the ankle joint motions are practically normal, unless the process is most extensive. There is, of course, the subsequent atrophy of the leg from disuse.

The swelling is usually not a fluctuating one, but is doughy and gelatinous in feeling.

The most frequent location of the disease is in the astragalus, followed in order of occurrence by the os calcis and lower end of the tibia, lower end of the fibula, scaphoid, cuboid and first metatarsal. These joints are working centers of weight bearing, and subject to constant friction, strain, over use and general wear and tear, and joints which transmit weight to the ground are usually more subject to strain, injury and disease than others.

When the astragalus is involved, it is usually its upper surface, which leads to involvement of the whole joint, including the lower ends of the tibia and fibula. Areas in the os calcis are more usually localized, do not involve the joint, and are as a rule not as serious an affection, unless the disease is virulent and attacks other bones.

Either the lower end of the tibia or fibula, near or at the epiphyseal line, may be the starting point of the disease, which then usually spreads to the whole ankle joint. Swelling localized about the internal malleolus usually points to a focus in the tibia, and about the external malleolus to a focus in the epiphysis of the lower end of the fibula. Swelling which obliterates

both malleoli usually means that the astragalus is involved, or at least the synovia covering it, as well as the lower ends of the tibia and fibula.

Marked swelling over the neck of the astragalus, and most prominent on the dorsum of the foot, usually points to an active process in that region, which later will probably extend and involve the ankle joint.

Foci of disease originating in the other tarsal and metatarsal bones of the foot are not frequent, and may often be limited to the bone in which they originate, or, if the virulence of the infection is great, may rapidly spread to the other bones and so involve the whole foot. In children the tarsal and metatarsal bones are largely cartilaginous, and so have slight resisting power and disintegrate rapidly, especially provided no treatment is undertaken from the start.

Abscesses occur frequently, and this probably is explained by the superficial position and small size of the bones involved, which conditions cause an abscess to form and break before the healing process of re-absorption has a chance to take place, as would happen in bones and joints of larger size in which the focus of disease is more deeply situated.

Following the opening of an abscess, there usually persists a sinus. Spontaneous rupture of an abscess is not rare, and in these cases a secondary mixed infection is the usual condition to be combated, and adds to the risk of any curetting operation.

Sinuses persisting after operation are not rare, but their presence depends a good deal on the extent of the operative procedure and the number and area of bones involved. A clean excision of a single bone with a single sinus, even if long existent, which removes practically all the disease, should lead one to expect a first intention wound, without subsequent breaking down, provided the after treatment is carefully and properly carried out.

The diagnosis of tuberculous disease of the ankle joint or tarsus is usually easily made. The cardinal symptoms are pain, soreness, limp, swelling and muscle spasm. When the ankle joint is involved, and when the disease has existed for any length of time, the foot is usually held in slight plantar flexion, with

obliteration of the outlines of the malleoli, and occasional inversion of the foot. Increased surface temperature is practically always present and redness when the disease is in one of the smaller superficial bones, or when an abscess has formed.

Chronic sprain, irritable flat foot, syphilis and infectious arthritis are to be ruled out by the history, x-rays and results of treatment. It is usually not difficult for one familiar with these conditions to make a correct diagnosis. Osteomyelitis may be confused with an active tubercular process, but presents the picture of a much more rapid and virulent infection, which requires immediate operative interference. Disease in the tarsal bones may be localized to one bone, and may be evident on inspection. Also it may have spread and involved the whole tarsus so that the whole dorsum of the foot is swollen, boggy and hot.

Disease of the lower end of the tibia, fibula or astragalus quickly involves the ankle joint and causes the characteristic swelling about the malleoli, the outlines of which are obliterated.

The pathology of tuberculosis of the bones of the foot is like that of all other bone tuberculosis.

Tuberculosis of the joints is a reaction of the tissues in and about a joint to the presence of the tubercle bacillus or its toxines. There are two theories: 1st, primary infection of the synovia, followed by extension from the synovia to the cartilage and bone, and 2nd, all joint tuberculosis is of primary bony origin, starting at the epiphyseal lines in the bone marrow and invading the joint secondarily.

The bacillus usually enters the respiratory tract, or may be in the intestinal tract, when it is usually derived from infected milk. The tonsils are also to be considered as channels of infection. At autopsy, the foci are usually found in the lungs, intestines, bronchial and mesenteric lymph nodes. General tuberculosis may result from a local bone infection provided the process is active and virulent, and the patient's resistance is below par. It may also follow after a curetting operation on the focus, or in a case which has had multiple sinus of long standing.

Following a mild injury, there is an inflammatory exudate

which offers the tubercle bacilli a favorable field for growth if it is already present in the body; while if the injury is severe the reparative processes are so active that the bacillus is destroyed even if it does obtain access to the injured part.

When the bones of the foot are affected, there is the usual formation of the tubercle, which breaks down and becomes caseous, due probably to the lack of blood vessels in the destructive process, and also to the action of the soluble toxines produced by the tubercle bacillus.

As noted before, these caseous masses, being in bones which are small and superficial, readily appear under the skin as abscesses. They may remain single or spread and coalesce, and cause extensive destruction of various adjacent bones of the foot.

Repair is brought about by formation of fibrous tissue which replaces or partly encapsulates the tuberculous tissue. This may become ossified, and so may result in bony ankylosis of the part involved.

Given a case of tuberculosis of the ankle or tarsus, the two most essential things to do are to prevent weight bearing and to enforce absolute rest. These two conditions are the sine qua non in the treatment of any tubercular joint condition, and without which very little is to be expected either for a cure or for a good satisfactory result.

The general condition is most important, also, and a healthy restful outdoor life, with plenty of nourishing food, is essential.

With disease in the bones and joints, considerable variation occurs in the virulence of the infection and the resistance of the individual, and where in one case acute and destructive disease exists, causing great impairment of function, in another the disease may run a very mild course and leave the patient with nearly a normal joint. There is no way of telling at first, however, which type exists, and so the routine is to be carried out in each case.

In order to get relief from weight bearing and to ensure rest of the part, a plaster cast is applied, with the foot at a right angle to the leg, from the toes to the knee. The child is then fitted to a Thomas knee splint, on which he may walk. He is also provided with a high sole for the well foot and

crutches. This is the routine outfit for protection and fixation of the joint.

Radical operations on the joints and bones in children are not the best methods of treatment, and conservative measures are to be carried out until radical operation is indicated, when all else has failed to stop the progress of the disease.

Operations then should be clean. No curetting should be allowed, and any bone or bones involved should be removed in toto, with as little mutilation as possible. The increased risk to deformity after an excising operation is of course obvious, whereas the non-operative cases which go on to a cure are much less apt to result in deformity, and then not of so serious a nature.

When small foci exist in bones such as the os calcis, the cuboid, the scaphoid and the cuneiform, which are not very active, a conservative course is to be followed. If the process is active and acute, often an incision to establish drainage will give the part an opportunity to heal and prevent extensions, but removal of the whole bone is not to be practiced unless the destruction is great, the process spreading or of long duration with a persistent sinus, for the subsequent deformity is of course greater. In some instances subperiosteal excision may be done, which allows the cavity to become filled with new bone in a shorter time than it would otherwise. In other cases the sinus may be dissected out, the sequestrum removed, and the bone cavity carefully wiped out with carbolic acid, followed by alcohol, or tincture of iodine may be used. Occasionally a first intention wound is obtained after this procedure.

Following a cure in either operative or non-operative cases, there may be deformities which may need correction. This is to be done by appropriate tenotomies or osteotomies, a sufficiently long time having elapsed to avoid any further lighting up of the original disease.

There is usually also some shortening of the foot from atrophy or disuse, which is generally slight, and also from removal of bone. The shortening is usually most marked when the astragalus has been removed. The other deformities noted are due in part to excisions of various bones and contractions of the

soft parts, and rarely follow any rule. In cases where certain joints are ankylosed, neighboring joints take up their work, and increase their range of motion, so that there is always a certain amount of compensation. For instance, if the ankle joint is ankylosed, the tarso-metatarsal joints will increase their range of motion to such an extent that there is considerable freedom in that joint, which condition of course makes for more ease and freedom in walking and a more flexible foot.

Conclusions.—1. Tuberculosis of the ankle joint and bones of the foot in children is insidious in its onset, chronic in its course, and attacks usually young children.

2. The expectant or conservative method of treatment is preferable to the operative one.

3. Time is saved and deformity less under the conservative plan than by the operative method.

4. There is also less danger of secondary joint development and general tuberculosis by pursuing the non-operative plan.

5. The disease may be associated with bone and joint tuberculosis in other parts of the body.

6. The prognosis is fairly good for life, but poor for a good ankle joint in which there is no disability.

7. A certain number get a good functional ankle, with but slight deformity.

8. In regard to the smaller metatarsal bones, the results are good for joint motion.

Tuberculosis of the Shoulder.—Tuberculosis of the shoulder joint is a rather rare condition especially in children. Of all the large joints, it is the most infrequently attacked. It may occur in children who have other tubercular foci in other joints or in the lungs. It rarely occurs before ten years of age, and it may follow as so many tubercular joints do, an injury to the joint from a blow or fall. A tubercular family history is of great importance.

Tuberculosis in the long bone such as the humerus usually starts in the epiphyseal line, generally in the marrow, and rarely in the cartilage or cortical bone. The focus extends towards the joint cartilage and perforates that into the joint, which process is followed by a general infection of the joint.

Trauma predisposes to infection, but a serious trauma seems to summon such quantities of defensive agents to the injured area that tubercular infection rarely results, while a slight trauma on the other hand often offers favorable conditions for the development of the tubercular process.

Susceptibility is at its height in childhood, and with poor heredity influences, predisposition, and poor environment, there may easily follow an infection. There are two methods which seem probable for the entrance of the bacillus into the system, namely—ingestion and inhalation, the throat, tonsils and adenoids being favorable channels.

Surgical tuberculosis is usually of the bovine type, probably comes from milk, and is the type which usually affects the bones, glands, peritoneum, ear and genito-urinary tract.

The onset in the shoulder is usually insidious, due to the slow growth of the diseased area. After the joint is infected, a pannus extends over the synovial membrane, spreading by an inflammatory process and prone to suppuration.

The onset is generally slow. Many cases at first are confused with chronic rheumatism, and the appropriate treatment consequently delayed. There may be local temperature as well as some slight constitutional reaction. Tenderness is an early symptom, usually over the anterior aspect of the joint, followed by a change in the contour of the joint, due to atrophy of the muscles of the shoulder girdle, and swelling of the joint. Impairment of motion is an early symptom, especially in rotation and abduction, due to reflex spasm of the muscles about the shoulder.

Reflex spasm is a most important sign. It appears early as a rule, and is most marked in the deltoid. It is easy of demonstration by attempted abduction of the arm. Atrophy is usually an early sign, and may be rapid and extreme, even involving the pectoral muscles. There may also be some glandular enlargement in the axilla. If the disease goes on to abscess formation, it may point in the region of the corocoid process, in the axilla, or even make its way down the arm, along the shaft of the bone, and appear on the surface anywhere in its upper third.

Pain may be the first symptom, but is usually noted at first only when the joint motion is attempted. It may be worse at night than during the day. It may extend to the elbow, following the course of the musculospiral nerve.

There are two distinct types of tubercular disease of the shoulder, namely, *Caries Sicca* and *Caries Carnosa*.

Caries Sicca is a type of disease which is more slow in its action, and generally destroys the head of the humerus and the joint, without abscess formation. The joint instead of being swollen is often diminished in size, from the bone destruction and constriction of the capsule. There is not so much tenderness, nor are the acute symptoms marked; but there is the usual loss of motion, and finally, ankylosis. These cases have at times been mistaken for an infantile paralysis involving the shoulder group of muscles.

In *Caries Carnosa*, however, the condition is more acute, and the tubercular process extends from the joint into the medullary cavity of the bone. The medullary tissue is replaced by fleshy granulations through which the tubercles are disseminated. This type is often acute and leads frequently to abscess, formation of abscess cavities in the bone, and formation of sequestra. The tubercular process may be either primarily synovial or may begin in the epiphyseal line. When it begins in the marrow of the epiphysis, the disease works towards the joint, breaking through the cartilage or spreading out under it, lifting it up, and invading the joint, finally at the periphery. Certain portions of the joint may be spared by the development of adhesions. Following the joint invasion, the synovial membrane is attacked, and the rest of the joint involved.

In the synovial type the synovial membrane is thickened and filled with tubercles. The extension then follows around the edges of the cartilages, and then later bone involvement. The type may exist for considerable time without extension to bone.

The diagnosis is usually easily made, and there is very little else that can be confused with this condition. Swelling of the joint, atrophy of the shoulder muscles, pain, local heat, limitation of motion especially in abduction, and reflex spasm are cardinal symptoms. The x-ray is of great value. One of the

first things noticed following a tubercular infection of bone is the atrophy of the shaft of that bone. This may occur before the focus can be made out. When the focus is more fully developed, it may be seen as an area of increased radiability. Osteomyelitis is usually of much more acute onset, with marked local and constitutional symptoms.

Articular rheumatism usually involves several joints, and is of more rapid onset. There is swelling but not atrophy. There is also muscle spasm, but not as marked as in tuberculosis, and there are no bone changes, such as abscess formation or atrophy.

For treatment, the essential thing is rest. The arm is to be flexed at the elbow, and held by a sling and circular bandage, or Velpeau. The weight of the arm in most cases furnishes sufficient traction. When abscesses form they must be opened, and any necrotic bone curetted and the cavity packed. When abscesses recur, and the bone destruction is extensive, the head of the bone must be resected. It is well to bear in mind that as the growth of the humerus is largely from the upper epiphysis, any resection of the head of the humerus or interference with the epiphysis before eighteen years of age will result in a considerable loss of growth of that bone. It is, however, always best to remove any diseased tissue, and endeavor to get a moveable joint. An arm slightly shorter than the other, but moveable, is better than a stiff one.

After operation, sinuses occasionally persist for long periods of time. The general treatment is of great importance as in all tubercular conditions.

The results of treatment vary considerably according to the type and severity of the disease. The loss of function also varies, according to whether the disease was synovial or bony. Abduction is most affected, then flexion and extension, and then adduction and rotation. Partial ankylosis is usually fibrous, while total ankylosis is usually bony. As a rule the fixing of the head of the humerus to the glenoid cavity of the scapula limits the ability to raise the arm from the side about one-third to one quarter of the normal. When the patient can get the hand to the head to dress and feed himself, the disability is not serious, and is little felt. The duration varies

from two to three years in favorable cases, and longer in the unfavorable ones. Relapses in cured cases are rare.

Tuberculosis of the Elbow.—Tuberculosis of the elbow is of more frequent occurrence than tuberculosis of the shoulder joint or tuberculosis of the wrist. It is, however, not as common as tuberculosis of the hip, knee or ankle. It stands about fifth in order of frequency of occurrence of tuberculosis of the joints. It is said to occur in girls more frequently than in

No. 99.—Tuberculosis of the Elbow with Sinuses.

No. 100.—Tuberculosis of the Elbow with Sinuses.

boys. It is also said to occur more frequently in the left elbow than in the right.

Trauma, as in all tuberculous joint affections, plays a most important part in the causation of this disease in the elbow. In the histories of most cases, there are many which may give a definite traumatic history. Again a tubercular family history is of great importance.

The average age of occurrence is of interest, showing that it occurs early in life, but slightly later than tuberculosis of the shoulder, ankle and wrist. The average age is about 5.3 years.

The primary focus is usually a bony one, the process extending from the epiphyseal line into the joint. The focus is generally found in the ulna in the olecranon, and close to the epiphyseal line and therefore close to the joint.

Any injury to the elbow such as a fall, sprain or bruise which does not clear up in the usual course of time should make one most suspicious of tuberculosis. The type of swelling is rather characteristic, and is almost invariably fusiform when the disease is at all advanced. It may begin about the insertion of the triceps, when the disease is in the olecranon, and extends above and below the elbow joint. When the focus is elsewhere, the swelling may be primarily over that focus, but eventually will assume the characteristic type as the joint is affected. Limitation of motion especially in extension of the forearm is an early and constant sign when the disease is in the ulna, whereas, pronation, supination and flexion may be free. If the head of the radius is the area involved, the swelling may appear either side of the tendon of the biceps, and supination, pronation and flexion are much limited. In any untreated elbow disease, the forearm tends to form an obtuse angle with the upper arm, and unless care is taken may ankylose in this bad position with about 125 to 140 degrees extension and more or less complete pronation. There is said to be a marked tendency to suppuration in tuberculosis of the elbow joint.

The disease may appear before or after other joint disease in the same case, and the infection may extend to another joint from the elbow, or to the elbow from the other joint involved with equal frequency. The general condition of the patient and the virulence of the infection have a good deal to do in determining the extension of the disease from one joint to another, and trauma may often open the way to infection in a joint in a case which already has other foci.

The diagnosis is usually easily made. The onset is slow, often following an injury. The swelling is fusiform and characteristic. There may be other joints involved. The surface temperature is increased. Joint motion in extension, supination and pronation is diminished or absolutely restricted, and the arm and joint are painful. Fractures may be ruled out by

means of the x-rays, and by the proper relation of the bony landmarks. Acute synovitis of the so-called rheumatic type has a more rapid onset, more pain, more constitutional reaction, and may involve several joints in turn. It also does not tend to develop abscesses, nor is the swelling as fusiform. Chronic non-suppurative arthritis will probably involve more than one joint, is slow in its onset, is not as painful, does not cause bone destruction, but causes considerable synovial thickening, and is not associated with so marked limitation of motion. Osteomyelitis is more rapid in its onset, is prone to suppuration, has marked constitutional symptoms, and gives the picture of an acute infection. The tuberculin test is of great diagnostic value, and should be used in all cases. The Von Pirquet skin test is the easiest and as reliable as any. The x-ray is of value and should be used in all cases to show the nature, location, and extent of the disease.

Motion or attempts at motion in a tuberculous joint tends to keep the process active and absolute rest should be enforced. This is best carried out by means of a plaster of Paris splint extending from the hand to the shoulder with the elbow at right angles and the forearm semi-pronated. After the active process has quieted down, a leather splint may be substituted for the plaster one. Frequently changing the splint is bad for the elbow, and any dressings that are needed for sinuses are to be done through windows cut in the splint. If the arm is in poor position to begin with in acute cases, a series of plasters applied in the best corrected position will gradually relieve the spasm and joint irritation, and finally, allow the arm to be held at a right angle.

If the conservative treatment does not cause a diminution in the activity of the disease, but involvement of other parts of the joint occur and abscesses form, then operation is to be considered. Abscesses of course are to be opened, and any necrotic bone excised. The cavity may be wiped out with tincture of iodine, and allowed to drain, or is to be packed. A number of cases of elbow joint disease, however, degenerate into a pulpy mass involving the whole joint, and portions of the bones above and below the joint. When this condition

exists, excision of the whole mass or resection of the elbow is to be considered. Children develop an extraordinary power of regeneration, however, and before resection is done, there are several things to be considered:

1. Is resection necessary, and if done can the whole diseased area be eradicated?

2. What is the general condition and what effect will the operation have on the child?

3. Will drainage and excision of the necrotic areas be sufficient to produce an ultimate cure without further extension or operation?

4. Will the ultimate result be justified either by resection or excision?

5. What is the time to be gained?

These points should be carefully considered in each case before radical operation. Resection, however, in old healed cases with a bad position of the arm is of distinct advantage. An arm in an extended position, fully pronated with an ankylosed elbow is not of much use compared to an arm with an ankylosis at a right angle and less pronation. An arm in this latter condition is of distinct benefit and is most useful. However, certain progressive cases develop such extensive necrosis about the elbow involving not only the bone but all the soft tissues and the skin that resection is the only thing to be done, not only to extirpate the disease, but to improve the general health, prevent metastases, and a later necessary amputation of the arm. The operation oftentimes is not a classical one, but owing to the condition of the individual elbow has to be atypical. The usual method of procedure is as follows: through a posterior longitudinal incision along the ulnar and lower end of the humerus, the periosteum is elevated, the ends of bone are exposed after freeing them of muscular and ligamentous attachments and displaced through the wound. They are then divided by means of a chain saw well above and below the areas of disease. The arm is then put up at a right angle, with the thumb up, and an ankylosis is to be hoped for.

Resection, however, is only to be undertaken as a last resort. Any excision that may be done should avoid as far as possible

the epiphyseal lines, for disturbance with these in a growing child leads to marked retardation of growth. However, as the more active growth in the humerus occurs in the upper epiphyses, a resection of the lower epiphyses does not seem to cause very much shortening of that bone, and as a rule there is not a great deal of shortening of the bones of the forearm. In cases seen early and put under proper treatment of rest and fixation at once, there is generally little likelihood of much extension of the disease. In these joints, areas of repairs and extension exist at the same time, and the simple drainage of an abscess is often sufficient to arrest further extension, care being taken to prevent a mixed infection.

Conservatism should be shown in any operative interference in tuberculous joint diseases, and often joints are made worse by too early operative interference. The treatment as in all tubercular cases must be of long duration and carefully supervised.

The results of treatment in cases of tubercular elbows as shown from a study of a series of cases are rather interesting and better than was to be expected. Motion was obtained to a greater or less degree in about half of the cases and any motion in the elbow joint after the quiescence of the disease is of course of great benefit. In weight bearing joints, however, like the hip or knee, slight motion is not a satisfactory end result, for there the condition is an unstable one, and from the consequent strain is likely to cause continual joint irritation, and possibly light up further active tubercular processes.

Cases which are operated upon for the opening and curetting of an abscess, or partial excision of the affected bones, may result in an ankylosed condition. Some have motion which could be called good, that is, about 40° of motion in combined flexion and extension with pronation and supination anywhere from one-third to three-quarters normal. The result of resection of the entire joint generally is that of ankylosis.

Cases treated by the so-called conservative method result usually in ankylosis in good position, that is, at a right angle, with the thumb up. Some have very slight motion in the joint,

that is, 5 to 10 degrees motion; some, a moderate amount of motion, 15 to 20 degrees in flexion and extension, and a few degrees in pronation and supination, or about one-third normal, and others show good motion, that is, about 40 degrees or more motion in flexion and extension, with pronation and supination, anywhere from one-half to wholly normal. If an ankylosed elbow is the best to be hoped for in these cases, except where resection has been practiced, I believe these end results are excellent.

In regard to the duration of the disease in the elbow joint, when associated with other tubercular bone foci, there has been apparently no marked increase in the time of convalescence.

No. 101.—Tuberculosis of the Wrist. Note swelling above wrist and at base of thumb.

The general condition plays so important a part that if it is properly looked after, there does not seem to be any undue continuation of the disease in the individual joint. One joint may go on to a convalescent condition while the other is in the active stage. It is rare to find two active bone foci together.

Tuberculosis of the Wrist.—Tuberculosis of the wrist is uncommon in childhood, but is more common in older subjects. It is rare as compared with tuberculous diseases of other joints. The cause of tuberculosis of the wrist is the same as tuberculosis of other joints, that is, infection with tubercle bacillus. The symptoms are swelling, heat, stiffness, pain, limitation of motion associated with muscle spasm, and atrophy. The treatment is fixation of the wrist by means of splints with support to the hand and arm in the attitude in which ankylosis of the

wrist will cause the least ultimate disability. This fixation can be best obtained by means of plaster bandages extending from the elbow to the tips of the fingers, or else by means of a leather splint which is made from a plaster cast of the arm and hand. A slight degree of dorsal flexion is the most favorable position.

Without treatment, abscess formations may occur, as well as considerable flexion deformity of the wrist, which deformity has to be corrected in order to insure a more satisfactory end result, and a minimum amount of disability. If abscesses form, they have to be opened, but delay for as long as possible in opening them is advisable. The prognosis in tuberculosis of the wrist, as regards function, in childhood is fair. In adult cases, the prognosis is not so good because the condition is apt to be associated with tuberculosis elsewhere, especially in the lungs. In children, conservative treatment by means of fixation and rest is by far the better method of attack. With adults with the progressive disease in the wrist, amputation of the hand is strongly indicated. If the disease, however, is localized in one or two of the carpal bones without evident extension to the other portions of the wrist, complete excision of the diseased area may prevent further extension of the disease, and give a good functional result. General tonic treatment of the individual is indicated in all cases of tuberculosis, and is of the utmost importance.

CHAPTER V

INFANTILE PARALYSIS. OBSTETRICAL PARALYSIS. VOLKMANN'S ISCHEMIC PARALYSIS. MUSCULO-SPIRAL PARALYSIS. SPASTIC PARALYSIS

Infantile Paralysis or Anterior Poliomyelitis.—Infantile paralysis is an acute infectious disease due to a filterable virus, accompanied in most cases by some paralysis more or less extensive. It is a disease occurring both in epidemics and sporadically, which usually affects children and young adults. It is more common in the summer months than at other times of the year. It results in an injury or destruction more or less in extent to the motor cells of the spinal cord in the anterior horns. As a result of the infection, hemorrhage greater or less in extent occurs in this region, and this hemorrhage, plus infection, leads to a damaging effect on the nerve cells. As a result of this, the nerve cells degenerate so that there is oftentimes a complete loss of motor control of the parts which are innervated from these areas. The most common age at which children have the disease is between two and three years.

Stages of Attack.—The symptoms are those of an acute infectious disease with fever, vomiting, constipation and considerable prostration. Oftentimes they may also have pain and tenderness in the arms and legs, and if the disease is situated high in the cord, the condition may resemble that seen in meningitis with retraction of the head. On the other hand, the child may go to bed at night feeling perfectly well and seeming well, and may wake up in the morning with an arm or leg paralyzed. At one time, the condition was known as "sleeping sickness."

The paralysis which occurs is the flaccid type, that is, the part which is paralyzed is limp and lifeless, but there is no change in sensation. It is purely a motor paralysis. One leg or both legs are more apt to be affected, in the order mentioned, than in any other type of paralysis, but any part may be af-

fected in any given case. There may also be a paralysis of either a part of the back muscles or abdominal muscles which later leads to considerable disability in walking and to the development of a lateral curvature. There is always a good deal of

No. 102.—Infantile Paralysis from Behind. Showing weakness of left leg with contraction of tendo-achillis. Foot in position of equinovarus.

No. 103. — Preventable Deformities from Infantile Paralysis.

tenderness on pressure over the part paralyzed which may last for five or six weeks, or even longer. It is an important symptom, and, until this tenderness has disappeared, it is not wise to start active treatment. During the convalescent and tender period, the part paralyzed of course should be supported in a natural position by means of a splint or plaster cast to pre-

No. 104.—Contracted Heel Cord from Infantile Paralysis. Talipes Equinus.

No. 105.—Calcaneo Cavus from Infantile Paralysis.

No. 106.—Talipes Equinus or Drop Foot with Contracted Heel Cord from Infantile Paralysis.

No. 107.—Infantile Paralysis with Hyperextended Knee.

vent contractions or deformities which occur from the contraction of the non-paralyzed and unopposed muscles.

Following an attack of infantile paralysis, there is always a certain amount of spontaneous improvement in the paralyzed

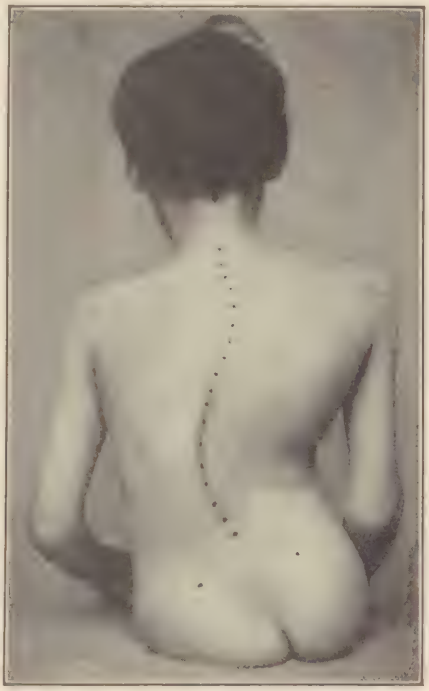
No. 108.—Calcaneo Cavus from Infantile Paralysis.

No. 109.—Infantile Paralysis of Left Leg from Front, Showing Toe Drop and Hip Flexor Contracture.

part which begins soon after the onset of the paralysis, and continues with or without treatment for an indefinite period. After the tenderness has gone and treatment has been begun, during the first year the improvement is fairly rapid. After that, while the treatment is continued, that is, massage and splints, there is a certain slow gradual improvement up to a certain point, beyond which it never goes, and the child or

individual is left with a perfectly definite weakness or paralysis of the parts which is permanent. As a result of paralysis of certain groups of muscles, there always develop certain deformities which are in direct relation to the paralyzed muscles, and which treatment is designed to prevent. These

No. 110.—Talipes Equinovarus or Contracted Heel with Inversion and Adduction of Foot from Infantile Paralysis.



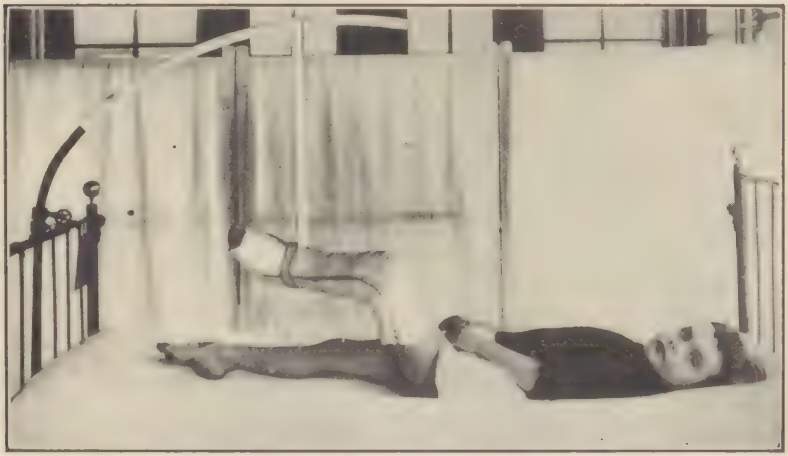
No. 111.—Scoliosis Due to Infantile Paralysis.

deformities are due of course to normal muscles, which being unopposed by the paralyzed muscles, stretch the parts into abnormal position. There is always a great deal of muscle atrophy, that is, the affected part becomes very much smaller, and there is a certain amount of interference with growth, not only due to paralysis but lack of normal use.

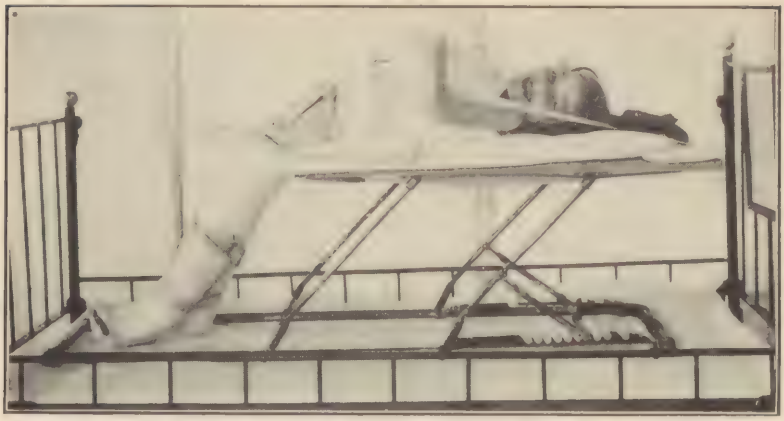
During the early stages while the patient is still tender, it is better to put him into some sort of apparatus like a plas-

No. 112.—Paralytic Dislocation of Hip from Infantile Paralysis.

No. 113.—Padded Box and Overhead Crane for Elevation of Leg Following Operation on Foot.



No. 114.—Method of Elevating Leg in Plaster Cast Following Operation on Foot, Thereby Preventing Congestion of Part and Making Patient More Comfortable.



No. 115.—Frame Used for After Care of Case of Infantile Paralysis, Following Division of Contracted Hip Flexors. Note cut plasters at knee with wedging for stretching knees.

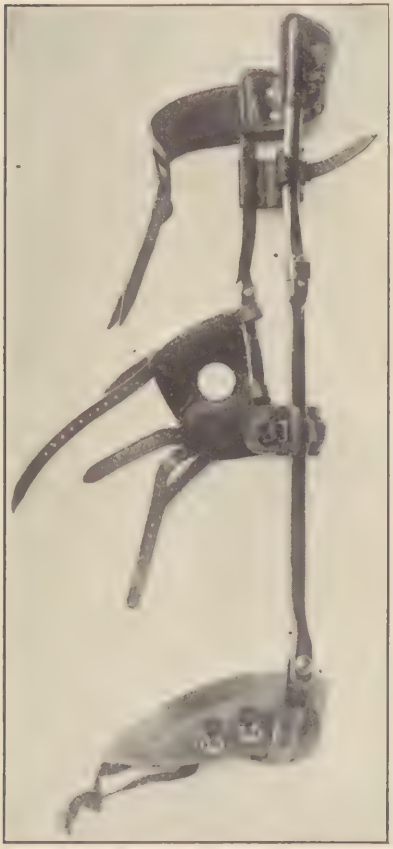
No. 116.—Double Walking Calipers for Case of Infantile Paralysis of Legs.

ter cast or splint which will support the limb or trunk in its normal position. The child should also be put into a warm salt bath daily toward the end of the tender stage which will give him a better opportunity to try to use the paralyzed part. This warm salt bath seems to give him a good deal of benefit, and apparently does no harm. Great care should be taken not to fatigue the patient because over-fatigue of the muscles

No. 117.—Walking Frame for Infantile or Spastic Paralysis.

which are paralyzed or partially paralyzed tends to make them deteriorate more rapidly, and a certain amount of muscle strength is permanently lost by so doing. Walking should not be advised or allowed if the legs are paralyzed, for a considerable period of time, probably several months. As soon as the tender stage has ended, massage can be begun with muscle training, and carried out as often as possible under expert attention, plus, of course, holding the part meanwhile in normal position with

braces. Muscle re-education unless properly carried out is worse than useless. If the child has abdominal weakness or paralysis of the back muscles, a plaster jacket or canvas corset has to be applied so as to prevent the development of bad



No. 118.—Brace with Outside Upright for Pronated Foot and Weak Thigh Muscles. Side view.

No. 119.—Brace with Outside Upright for Pronated Foot and Weak Thigh Muscles. Front view.

scoliosis. Beyond this point, the problem becomes definitely surgical in character, and that need not be dealt with here.

Obstetrical Paralysis.—Obstetrical paralysis was first described by Smellie in 1768, but was brought to the attention of the medical profession in 1872 by Duchenne, who described four cases.

The condition is a paralysis produced during birth, and is due to an injury to the nerves of the brachial plexus.

The paralysis is due to injury of the brachial plexus, due to forcible separation of the head and shoulder, resulting in a tear of a greater or less extent of the cords of the brachial plexus. This has been confirmed by operation, by autopsy on cases, and by experience. The resultant paralysis is characteristic. The arm hangs limp at the side, the elbow extended, the forearm pronated, and the whole arm inwardly rotated. The paralysis is usually flaccid.

No. 120.—Typical Upper Arm Type of Obstetrical Paralysis. Note inability to elevate, abduct, outwardly rotate and supinate hand and arm. See Nos. 121 to 128 inclusive.

It has been conceded by practically all authors that a difficult labor is a predisposing factor in the causation of paralysis. The labor is usually long and difficult, with ether and forceps. All the conditions noted above imply the application of force combined with great muscular relaxation of the child, conditions peculiarly favorable for the production of such an injury. A moderately large number have had the head delivered naturally, but the "shoulder stuck," and at that time force was applied.

The presentations are generally vertex or face presentations, and about a quarter breech, the latter classification including versions and footlings.

A condition of unequal pupils is probably overlooked in some cases, and is a most important symptom, in that it means, through injury to the cervical sympathetic, definite injury to the plexus, either of the lower cords, the eighth cervical, or first dorsal which have communicating bands with the cervical

sympathetic, or injury in the spinal cord itself, to the fibres of the sympathetic system. The prognosis in these cases is usually not so good as in those which do not show this sign.

There are generally two well recognized types of paralysis seen. The more common consists of a lesion which involves the fifth and sixth cervical roots and the supra scapular nerve, and produces a paralysis of only the muscles of the upper arm, with the exception of the supinators. This type is known as

No. 121.—Same as No. 120. Eight Years Later. Obstetrical paralysis with contractures about shoulder.

the "upper arm type." The less usual type, the so-called "lower arm" or "whole arm type" is the result of injury to not only the fifth and sixth cervical roots, but the seventh and eighth and possibly the first thoracic as well. Here the whole arm is flaccid, there is a wrist drop and paralysis of the small muscles of the hand. There occurs also, rarely, the pure lower arm type of paralysis, without any involvement of the upper cords of the plexus, the so-called "Klumpke's" paralysis. These cases show a paralysis which is usually the result of stretching of the plexus from over-extension of the head in cases of face presentation, and due to injury to the lower cords of the plexus, namely, the seventh, eighth cervical and first dorsal roots. They may at times be bilateral. It is in this type that one often

sees inequality of the pupils, owing to the fact that the sympathetic fibres from the deep cervical ganglionic plexus enter the spinal cord through the first dorsal and at times through the eighth cervical roots. Injury, therefore, to these roots leads to an unopposed action of the motor oculi nerve.

No. 122.—See No. 121.

Pathologically in the milder cases, the stretching or tearing forces results in a greater or less degree of hemorrhage or edema into the nerve sheaths. In others there may be a rupture of the perineural sheath, accompanied by hemorrhage into the substance of the nerve trunk, associated with a tearing apart or a separation of the nerve fibres. This latter condition leads, of course, to a permanent impairment of function, and the formation of scar tissue in the nerve tract. In the more severe cases of the upper arm type there is a partial or complete division of the fifth and sixth cervical roots, which leads to a more permanent form of paralysis than usual, and the formation of a more extensive area of scar tissue.

No. 123.—See No. 121.

It has been shown that traction and forcible separation of the head and shoulder puts the upper cords, the fifth and sixth cervical roots of the brachial plexus, under dangerous tension. This tension is so great that the two upper cords stand out like violin strings. Any sudden force ap-

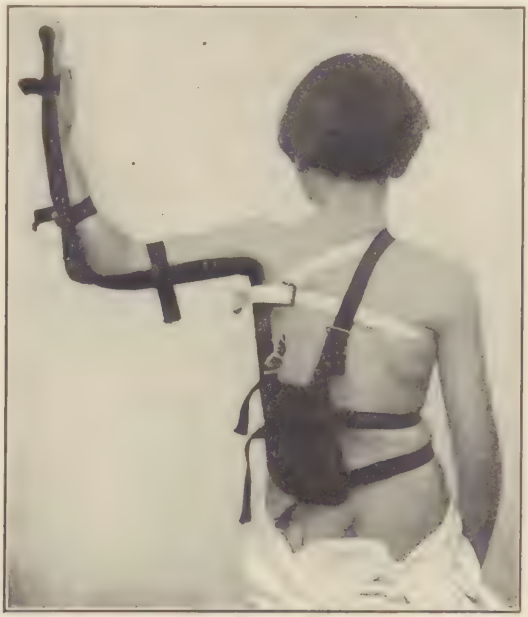
plied with the head bent to the side and the shoulder held, would without question injure these cords. It has also been shown that forcible abduction and elevation of the arm and shoulder put the lower cords of the plexus, the eighth cervical and first thoracic on a stretch, and when much force is applied, it may well lead to a tear, rupture or other injury to these segments. This

No. 124.—Same Case as No. 120. Splint Used After Operation. Front view.

condition is seen in breech cases, with arms extended. It may also follow sudden strain when the arm is elevated, such as the so-called "hostler's paralysis, caused by the sudden elevation and strain of the arm which occurs when a hostler holds a rearing horse.

With the shoulder held and the head carried to one side, with the clavicle intact, considerable force is necessary to injure the plexus. The suprascapular nerve always snaps first, apparently for the reason that it has not so much freedom of

play as the others. A fractured clavicle, of course, allows the weight of the shoulder to drag on the plexus and so predisposes to greater injury from traction. Rotation of the head combined with forcible abduction apparently does not increase the degree of tension greatly, certainly not enough to cause additional damage. Most birth fractures occur in the clavicle, or in the humerus, at about the junction of its upper and middle third.



No. 125.—Same Case as No. 120. Splint Used After Operation. Back view.

At birth, the shaft of the humerus is nearly wholly ossified but the two extremities are cartilaginous. The scapula at birth is largely osseous, with the exception of the glenoid fossa, the coracoid and acromial processes and the posterior border and inferior angle, which are still cartilaginous. It is an account of these conditions that fractures in these regions, at birth, are practically non-existent. It is not possible to produce a paralysis of the Erb type by the fracture of any bone but the clavicle.

A study of x-rays taken in cases of obstetrical paralysis shows the following conditions:

In the first year there is usually nothing seen of bony deformity. There may be a slight posterior subluxation of the shoulder joint, but there is never any acromial deformity evident by x-ray, or clinically. No case has been observed where the

No. 126.—Same Case as No. 120 After Operation. Note improved use of arm.

epiphysis has been displaced as far as could be seen by comparison with the normal shoulder. The epiphysis, as well as the shaft of the humerus is always smaller than the unaffected side, which condition is undoubtedly due to atrophy from disuse.

The scapula is practically always elevated and outwardly rotated, due apparently to the pull of the intact inward rotators and the levator anguli scapulae.

As time goes on and the child gets older, one begins to see increasing evidence of bony deformity, occasionally more joint

No. 127.—Same Case as No. 120 After Operation. Note improved use of arm.

subluxation than at first, increasing outward displacement and elevation of the scapula and acromial deformity. The deform-

No. 128.—Same Case as No. 120 After Operation.

ity of the acromion consists of a bending downward and forward, or hooking of its outer end, which apparently having

no bony resistance to meet as normally in the head of the humerus, projects downward in front of the subluxated and inwardly rotated head. This hooking seems to vary directly with the degree of posterior subluxation and inward rotation of the humerus, and tends to increase as the child gets older, provided subluxation is present.

When the child is first seen, if within a few days or weeks after birth, the following picture is classical of the upper type: the arm lies limp at the side, extended, and is inwardly rotated, with complete inability to abduct, elevate outwardly, rotate, or supinate. The muscles paralyzed in the typical upper arm type are as follows: deltoid, supraspinatus, infraspinatus, teres minor, biceps and supinator longus, and occasionally the serratus magnus coraco-brachialis and supinator brevis. The arm cannot be actually flexed at the elbow, but as a rule the lower arm is not affected so far as flexion and extension of the wrist and flexion and extension of the fingers goes.

No. 129.—Typical Case of Lower Arm Type of Obstetrical Paralysis. Note paralysis and contracture of hand.

The inability to raise or abduct the arm at the shoulder is due to the paralysis of the deltoid and supraspinatus, outward rotation cannot be accomplished because of the paralysis of the infraspinatus and teres minor and the arm cannot be internally rotated owing to the internal rotators, namely, the teres major, the subscapula, and the latissimus dorsi, being already fully contracted, due to lack of opposition.

The arm cannot be flexed at the elbow owing to the paralysis or weakness of the biceps, brachialis anticus, coraco-brachialis and supinator longus, and supination cannot be carried out,

owing partially to the inward rotation in which the arm is held, and the weakness or paralysis of the biceps and supinator longus or brevis.

In regard to sensation, it may be stated that it has been impossible in the early cases to determine any changes from the normal on account of the age of the patient. During the first week in the early cases, the child may cry if the arm is handled or moved, especially in abduction, but this soon disappears. In one or two cases there has been some swelling and tenderness noted by palpation over the plexus, above the clavicle. This condition, however, apparently has no connection with the degree of paralysis present. The hand grip is usually good, and the child flexes and extends the wrist and fingers well. The later developments in the upper arm cases, as the child grows older and develops, with or without exercises and massage, are as follows: the persistence of the inward rotation and adduction deformity; the so-called "policeman's tip" position; the inability in most cases to fully or freely supinate; the inability to get the hand to the mouth, without raising the elbow, due to inability to outwardly rotate; and the inability to put the hand to the head or behind the back.

In the lower arm type, all these conditions hold besides the additional ones due to the paralytic conditions of the lower arm and hand, resulting generally in a useless dangle arm.

Atrophy of the muscles in these cases of obstetrical paralysis is never very marked except in some cases of the lower arm type. One never sees the extreme atrophy so noticeable in cases of infantile paralysis. This lack of marked atrophy is undoubtedly due to the fact that the nerve impulses are rarely fully blocked, and that the muscles practically never, except in rare cases, wholly lose their entire innervations. Some normal nerve impulses pass through the scar tissue at the site of the lesion, owing to incomplete destruction or injury of the nerve and so keep the muscle tone up to a certain point. There is always a definite shortening of the arm in all cases, however, due probably as much to nerve injury as lack of use.

In the classification of whole arm or lower arm type, are placed those cases which show any nerve involvement beyond

that usually shown by an injury of the 5th and 6th cervical roots. Pupillary inequality and narrowing of the palpebral fissure are not unusual with this type. Wrist drop is the usual condition associated with the usual inability to supinate, and the additional inability to extend the lower arm. Paralysis of the flexors and extensors of the wrist and fingers is common, associated with paralysis and atrophy of the intrinsic muscles of the hand. Often the proximal phalanges are hyperextended, and the distal ones flexed, due to the paralysis of the interossi or lumbricales muscles. There is, of course, no power to grip and the fingers cannot be moved. There usually is ulnar displacement or adduction of the hand. These cases, almost without exception, represent severe tearing injuries to the roots of the plexus, and although some of the muscles may recover in part, particularly the upper arm and shoulder groups, the lower arm cases practically never recover, even after attempted operative repair of the plexus. It is in these cases that sensation is more apt to be impaired than in the usual upper arm type.

The treatment of these cases at once resolves itself into two divisions: i. e., those to be treated with massage and exercises, principally those of the upper arm type; and those to be treated by operation on the plexus, usually those of the lower arm type. Unless the early treatment has been adequate, the upper arm type will also come to operation, not for plexus repair, but to correct contraction deformities. This operation, which has been devised by the author, will be spoken of later.

At first in order to prevent contraction of unparalyzed muscles, it seems best to put the arm at rest in a position where such muscles cannot become contracted. This may be done by holding the arm in a plaster cast, or by the use of a light wire splint, in an abducted, elevated or outwardly rotated position, with the hand supinated. This position can be maintained, between massage and gymnastic treatment, and insures a better subsequent position of the arm. It also takes the drag off the paralyzed muscles, allowing them to regain their strength more quickly, and prevents subsequent shoulder joint deformity, such as subluxation and acromial hooking.

Massage and exercises are of the greatest importance and should be done daily if possible. It is most unwise to allow a child to become obsessed with the fact that it has an arm which cannot be used. The mother is instructed to dress the paralyzed arm first and undress the well arm first. She is told that each time she takes up the baby for nursing or other reasons, to straighten out the fingers and wrist, and supinate the forearm, as shown. Later she is shown how to abduct, outwardly rotate, and elevate the arm. One has to be guided by the intelligence and adaptability of the mother, as to when it is wise to allow her to perform these motions. A very good rule to give her is not to do anything with the affected arm that she does not see the well arm do.

Passive and Active Exercises.—The child is laid on a padded table and the arm or arms undressed. Beginning with the fingers and working up the arm and over the scapula, massage is given to increase the circulation, and nutrition. Then each finger and thumb, first separately and then collectively, is extended and flexed, at the same time singing some kindergarten song or nursery rhyme. (It is natural for babies to play with their fingers, so impress upon them from the beginning that they have two hands) such as "This is little Tommy Thumb, round and fat as any plum. This is little Peter Pointer, surely he's a double jointer. This is little Toby Tall, he's the biggest one of all. This is little Ruby King, she's too fine for anything. And the little wee one maybe is the little finger baby." Then collectively, "The little birdies in their nest go hop, hop, hop, hop, hop. They try to do their very best, and hop, hop, hop, hop, hop." This is just an example. Any suitable rhyme may be used, but must be sung with life and enthusiasm so as to impress upon the baby the association of the song or rhyme and the movement. It is surprising how early they learn the association of ideas.

To train the extensors of the wrist we sing: "This way, that way, blows the weather vane; this way, that way blows and blows again. Turning, pointing, ever showing, how the merry wind is blowing." The emphasis is, of course, always put on the motion necessary to train the weaker muscle.

For the supinators, sing, "Roll over, roll over, so merry and free. My playfellows dear, come join in my glee."

For flexion and extension at elbow, we sing, "Up, down, up down, this is the way we go to town. What to buy? To buy a fat pig. Home again, home again, rig-a-gig gig."

Abduction at shoulder or yard C position of educational gymnastics, excepting we supinate the forearm, sing "One yard ribbon, two yards ribbon, three yards, four yards, and tie a big bow on your hair." Elevation of arm: "Ready rockets! Shoot!" Repeat six or eight times. This is the same as arms upward stretch. Starting with the arms bent or flexed at elbow, stretch straight above head with palms facing each other.

For abduction at shoulder, hold the arm externally rotated, semi-flexed at elbow, with forearm supinated. Bringing to full abduction and then to body, somewhat after the manner in which the old-fashioned pump worked, sing, "Pump the water, pump the water. Pump, pump, pump."

For external rotation we hold the forearm flexed at right angles, with forearm supinated and upper arm close to body of child. Then carry it back till the thumb touches the table, and returning to starting position, describing a little semi-circle downward, singing, "Grind the coffee, grind the coffee, grind, grind, grind." While circumducting the arm, "Crank the auto (up), crank, crank, crank."

This covers all the motions of the upper extremity. Each case requires special emphasis on different motions. This rests with the condition of the arm, and must be left to the operator's judgment or the doctor's prescription for treatment.

Where one finds a contracted pectoral, subscapularis, or teres major, one must be sure to fix the scapula while elevating and externally rotating the humerus. A contracted pectoral in a baby is readily overcome by faithful treatment. The older babies and children seen (one to twelve years) usually have contractures of the pectoral, subscapularis, and teres major, and occasionally of the pronator radii teres. These cases, in addition to the treatment described, are put up in a wire splint, which fits over the pelvis and holds the arm in position

of external rotation, semi-flexion and supination. These children are given hanging on stall-bars.

In the whole or lower arm type, it is advisable to give three months' treatment, and if the fingers do not then show a tendency to recover, it may be well to explore the brachial plexus and repair the nerve if possible. These latter cases are most discouraging. No improvement is hoped for before a year. I have seen a few of these babies begin to have the slightest amount of flexion of the fingers in from six to twelve months, and very slowly improve. By the end of the third year, they are beginning to build blocks. It is the feeling of nearly all the medical profession that it is useless to do any nerve surgery in these cases. When these children begin to get motion in their fingers, they are taught to build with blocks (using colored blocks 2″ square), put large colored pegs in a peg-board, and string beads (the large colored kindergarten beads). A case of upper arm obstetrical paralysis can be taught to build blocks as early as five or six months, provided their training has been started early. After giving the child the exercises, we again give the arm massage to rest the muscle.

Children naturally are imitators and live in the land of make-believe. When treating children between two and six years, if the operator will have sufficient sympathy and co-operation with the child, she will find the child the greatest help in improvising games. All she will have to do is to direct the execution of the movements so as to bring into play the muscles which she wishes to develop. When treatment has not been started until after the child is a year and a half old, the first thing the operator must do is to gain the confidence of the child. Once this is accomplished, there is pretty clear sailing. Never deceive a child. Using tact and being sufficiently patient and sympathetic, one can get the child to try to do everything, and to allow you to exert considerable strength in stretching contractures.

The treatment should be continued for several years at least, and if contractures develop in the subscapula and pectoralis major, they must be divided before any further range of action in the arm is to be hoped for.

In regard to the operation on the plexus in the usual upper arm type of case, it might be said that experience has found it unnecessary. In the lower arm type of cases, the situation is quite different. Also it cannot be too strongly emphasized that no operation on the plexus will be of any great use in restoring functional activity to the arm, unless contracted and restricting muscles are divided, and careful after-treatment persisted in for a long period.

In regard to the operative treatment on the plexus in the lower arm type of case, it may be stated that it has been done a number of times without any benefit. The plexus in all cases was found to be so badly torn, and so bound down and invaded by scar tissue, that any kind of repair was impossible. This may be due to the fact that in the first place the plexus was impossible to repair, and secondly, granted that the plexus repair was in part possible, the muscular contractures and joint deformities were not recognized and properly treated, without which the plexus repair would be a waste of time and effort.

The prognosis in all upper arm type of cases is good, provided the case is watched from the start, and the treatment properly carried out. They are all practically able to raise the arm to the shoulder level and can use the hand and lower arm well, except for varying degrees of supination. Abduction and outward rotation are rarely regained without division of the contracted muscles provided they have been allowed to contract.

In the lower arm type, the outlook is not as good, although many of the cases regain use of the upper arm in spite of the persistent paralysis of the lower arm and hand. These cases should all be explored for repair of the plexus as far as possible, but even then very little hope can or should be held out to the parents. The general principles of treatment should, however, be carried out over a long period of time. Much can be done along orthopedic lines for these cases, and they should not be generally neglected as they have been in the past, with the statement that nothing can be done, or that they will get well of themselves.

Volkmann's Ischemic Paralysis.—In 1869 Volkmann first described the clinical picture of a contracted wrist and hand following a fracture, with atrophy of the forearm, known since as Volkmann's paralysis or contracture. His first case, however, occurred in an acute synovitis of the knee, following the application of a ham splint. The gastrocnemius muscle showed diminished electrical reaction and a moderate amount of contracture, which improved without operation.

Volkmann has laid down the statement that the condition follows the use of too tight bandages, usually after fractures, particularly on the arm, and occasionally on the leg, and that the paralyses and contractures are ischemic in origin, due to the cutting off of the arterial blood supply. He states that the paralyses and contractures generally come on together while paralysis due to nerve pressure comes on gradually. There is always great rigidity of the muscles from the first, due to great swelling, so that the part has a woodeny feeling. The ischemia is not complete, in that the part does not become gangrenous. The condition may also be seen after ligation, rupture and contusion of the blood vessels, due to an embolus or thrombus of the brachial artery.

The late Dr. Murphy of Chicago stated that he believed the condition was due to a blood and serum effusion in the subfascial zone, which caused cyanosis of the whole arm from pressure, followed by inflammation of this blood clot. The pressure, caused by this effusion, results in muscle cell destruction and necrosis, aided by tight bandages and splints. He believed that tight bandages, aided by tight skin and fascia, caused the damage, which is practically all accomplished in the first forty-eight hours. In other words, it is a traumatic myositis, resulting in permanent destruction of muscle tissue and so contractures, with or without nerve involvement in the scar tissue so formed.

Most frequently the condition is seen following fractures of the lower portion of the humerus and the bones of the upper forearm in children. The supracondylar region of the humerus seems to be the region of election, and the majority of cases seen are under fifteen years of age.

The irreparable damage to the muscle is accomplished within the first three days, but the full extent of the contractures does not appear at once. The damage is always done on the flexor surface of the part and is a flexor contracture and never an extensor contracture.

There is almost always some impairment of sensation or paralysis of the small muscles of the hand, due to nerve involvement or injury at the time of the accident. The pathological muscle changes represent typical hyaline degeneration and disappearance of muscular tissue in varying degrees, according to the severity of the original process.

After a fracture, usually of the lower end of the upper extremity, which has been splinted and bandaged, there may be noted incipient swelling of the part, with stiffness and cyanosis of the hand, fingers and forearm. There is almost always marked and intense pain, more than can be properly due to the fracture per se. These conditions are soon followed, if the bandage and splint are not removed, by limitation of motion, and then complete loss of motion in the hands and fingers. The swelling may subside of itself, if the splint and bandages are not removed, but greater damage will probably be produced, and pressure sores are likely to result. If, on removal of the bandage and splint, great swelling is present with a very tight skin, free incision into the forearm through the fascia and down to the muscles should be made in order to relieve the tension. Probably in some cases this procedure would be of great help and relief.

Many methods have been tried to relieve the contracture, but none has been wholly successful. As the arm grows, the muscles and tendons become relatively shorter and so lead to greater contractures of the hand. The bones of the forearm have been shortened in a number of cases with and without benefit. Tendon lengthening has been tried and again has proved to be of use in certain cases, but is a long and elaborate operation, and is quite likely to lead to more adhesions. The method which seems to offer the best result is the one which divides the muscle bellies by free incisions and so lengthens the tendons.

The after treatment is of the greatest importance and consists of the use of a palmar and dorsal splint to prevent and reduce the contractures of the wrist and fingers; electricity, galvanic and faradic, if there be nerve involvement, and massage and manipulation. Treatment should be long continued, but in many cases the benefit to be derived from any or all of these methods is not very great, and it is only rarely that a very useful hand is obtained. The results, however, are much better than if nothing had been attempted.

Musculo-spiral Paralysis.—This condition is not very rare and usually follows fracture of the middle third of the shaft of the humerus. The musculo-spiral nerve, as it passes around the humerus from behind and on the inner side of the humerus, downward, outward and forward in the musculo-spiral groove to the outside of the humerus, becomes involved in the callus or impinged on by a spicule of bone. Involvement of the nerve and subsequent paralysis may follow fractures of the upper third and lower third of the shaft of the humerus, but its occurrence under these conditions is very infrequent. There may also be a paralysis produced by direct pressure on the nerve by its being forced against the shaft of the bone by injury.

Its occurrence is a serious accident and complication of a fracture, and usually calls for careful study and possibly surgical interference. It is a condition which may be overlooked at first, and is not usually noticed until the splints are removed from the arm, and the patient attempts to move his hand, when it is noted that there is paralysis of the extensor group of the lower arm and hand, resulting in the typical wrist drop. The hand is held pronated and there is no power to supinate or extend the hand at the wrist.

The paralysis is usually wholly motor, even when the nerve is greatly injured. There may be some slight impairment of sensation, but it is never very great. The reason of this preservation of the sensation, when the nerve is so greatly injured, may be attributed to the fact that the cutaneous branches leave the trunk of the nerve above the fracture, and probably carry sensation to the radial half of the hand. Sensory symptoms

have no relation to the amount of motor impairment. When loss of sensation is present, it may usually be found in the distribution of the radial nerve in the hand, namely, on the dorsum between the metacarpal bones of the thumb and forefinger.

If the nerve is torn at the time of fracture, there is, of course, immediate loss of function, and paralysis at once appears. If due to involvement in the callus or pressure from bone spicules, the onset is more gradual and will probably not appear until about the beginning of the third week. Injury to the nerve from impingement against the bone causes immediate paralysis as shown by a wrist drop.

The prognosis is usually good if the condition is recognized early. About 50 per cent of the cases require operation. Others get well without one. In cases where involvement in the callus is the only condition present, the result from operation will generally be perfect. In others, where the paralysis is due to tearing, stretching, or complete section of the nerve with separation of the ends, an early operation offers better results than a long deferred one, but even with nerve suture or nerve lengthening, the results may not be ideal or even good.

Increasing paralysis demands surgical intervention in these cases, as well as a paralysis which shows no tendency towards improvement. After treatment is always of the greatest importance, and is to be carried out by means of massage, electrical stimulation, baking, and active motion as far as possible. A splint to support the hand is essential. This splint may be applied so as to hold the hand in a straight line with the arm, or better still, one which holds the hand and wrist in a hyperextended position, so as to take all possible strain off the weakened extensor muscles of the lower arm.

Spastic Paralysis.—The disease is known as spastic paralysis, cerebral paralysis, and Little's disease. Motor disturbances in children which are due to cerebral lesions are manifested clinically in three ways: 1, as single hemiplegia—paralysis of one side of the body; 2, diplegia—paralysis of like parts on each side of the body; 3, paraplegia—paralysis of legs and lower part of the body.

Congenital spastic paralysis is rare. Spastic paralysis as usually seen is due to cerebral hemorrhage, usually the result of a difficult labor, and consequent lack of development of the brain. Noncongenital spastic paralysis may follow cerebro-spinal-meningitis or chronic hydrocephalus. The onset may resemble infantile paralysis. It may develop after an infectious disease such as whooping cough, scarlet fever and diphtheria, or after a fall or blow on the head. The onset may be marked by convulsions, delirium or screaming spells. Paralysis is usually hemiplegic, and the arm is generally more affected than the leg. Strabismus or cross-eye is common. Mental enfeeblement varies from complete idiocy to simple backwardness. It may show in excessive irritability, mischievousness or destructiveness. Epileptic attacks occur in one-quarter to one-half of the cases.

The condition is due to embolism or hemorrhage, retarding the growth of the brain together with secondary changes in the spinal cord. There is muscular rigidity and sensitiveness.

The prognosis depends on the extent of the central lesion. If there is marked impairment, surgery is of little use. If there is no mental impairment, much benefit may be gained from surgery.

In most cases, the patient may be taught to stand and walk with or without apparatus. Functional disability may be reduced by treatment carried out for a long period of time. The correction of deformities helps in all cases to restore function. Few if any cases can be restored to a normal condition due to the fact that there is no treatment possible for the permanent lesion in the brain, which is the cause of the spastic condition.

Many cases fail to live many years. Those which are paraplegic or diplegic usually die before the age of twenty, and but few of the hemiplegics reach forty. The milder types of these classifications, however, may exceed these limits.

The treatment of spastic paralysis is wholly orthopedic. The main purposes of treatment are to stimulate the nutrition of the paralyzed parts, by means of muscle training exercises designed to create coördinate movements, and stimulate the over-stretched muscles in the direction of their functions. The mentality of the patient is of the greatest importance, for the measure of

success of any treatment depends on the ability of the patient to coöperate.

No. 130. — Case of Spastic Paralysis with Mental Deficiency.

The paralysis in these cases is quite different from that seen in cases of infantile paralysis. In infantile paralysis, the part affected is limp and flaccid, whereas in spastic paralysis, the limbs are held stiffly, especially with contractures of the flexor and adductor groups. There is also marked loss of muscular coördination in that the patient cannot control his movements either in the normal use of the hands and fingers, or the use of the legs in walking and standing. The gait varies from a mild limp to an extreme rocking jerky gait so long as there is any ability to walk at all. In the bad cases, there is a total inability to walk or stand, due to the great extent of the cerebral damage.

No. 131.—Case of Spastic Paralysis.

There is never the same degree of atrophy seen in these cases as seen in cases of infantile paralysis, due to the fact that the centers of nutrition of the paralyzed muscles are not involved. Therefore the muscles do not become wasted, and the circulation to the part is not impaired. There is, however, some change in

the size of the part affected, due largely to loss of normal function.

Children affected with spastic paralysis begin to walk later than their normal fellows. Many cases of the milder types are seen first because they have not begun to walk at the usual age and are brought to the doctor because of that fact. It is then found that there exists some degree of spasticity, of the arm or leg, combined generally with a varying degree of mental impairment.

Once walking has begun, the following conditions or deformities may be noted: walking, on observation, is awkward; the gait is a shuffling one, the knees and hips may be partially flexed, and the legs adducted, so much so that there may be a so-called "scissors gait," and one foot or both may be held in a position of equino-varus, with a contracted heel cord. There is also a distinct lack of normal muscle balance, due to the brain lesion which makes the equilibrium of the individual most unstable in the upright position. In contrast to infantile paralysis where the deep reflexes are abolished, the knee jerks and other reflexes are exaggerated in cases of spastic paralysis.

The loss of muscle power in cases of spastic paralysis is not great, but is simply uncoördinated and uncontrolled due to the fact that the motor impulses going to the affected flexor and adductor groups are so overwhelming. Walking, therefore, is possible except in the most severe cases, but as before noted, the patient walks with a limp of varying severity. The loss of proper use of the hand and arm generally constitutes a rather severe disability. The patient may be able to abduct the arm at the shoulder, and partially extend the lower arm, but there is generally some permanent flexion deformity at the elbow. There is also a marked inability to supinate the hand or to extend the wrist or fingers, which are usually held flexed. The finer coördinate movements of the hands and fingers cannot be performed.

Surgical measures are often necessary to overcome contractures, supplemented by splints to maintain the corrected position. Stretching of contractures by means of casts or splints, without operations, may often correct deformities. If stretch-

ing procedures do not suffice, operations such as tenotomies or myotomies may be performed, followed by casts and later by massage, baths and muscle education. The Stoeffle operation, which divides certain of the motor nerves which go to the contracted muscles, and so reduces the power of the over-acting muscle, is of use and may prove of the greatest benefit. In certain cases, it is to be preferred to tenotomies.

CHAPTER VI

INTERNAL DERANGEMENTS OF THE KNEE. PREPATELLAR BURSITIS. DUPUYTREN'S CONTACTION. SYNOVITIS OF THE KNEE JOINT. GANGLION. TENNIS ELBOW. SUBDELTOID BURSITIS

Internal Derangements of the Knee.—In the knee joint, there are two crescent-shaped discs of cartilage placed on top of the tibia, and known as the internal and external semilunar cartilages. These cartilages deepen the articular surfaces on top of the tibia, and are very much thicker on the outer border than they are on the inner, where they taper down to a narrow edge which is thin and free. These cartilages are very apt to become injured, particularly the internal semilunar, as a result of some trauma to the knee. This trauma may be a severe twist with the lower leg abducted, the thigh inwardly rotated, and with the weight placed upon the foot on that side. This puts a tremendous strain on the internal lateral ligaments, and tends to tear open the knee joint on its inner side. It is at this time that the cartilage may be caught or torn, and the knee locks in flexion so that the individual cannot fully extend the lower leg upon the thigh because of the fact that the cartilage is caught between the tibia and femur. The cartilage, as a result of this injury, may be split or fractured, or completely torn from its attachments. Occasionally the cartilage may be reduced immediately after injury by someone pulling on the leg, but more often it has to be done by a surgeon. The knee, following such an accident, may become distended with fluid, and a condition of acute synovitis of the knee joint, associated with more or less hemorrhage, occurs. This condition requires the usual treatment for such an injury, that is, fixation and rest. Occasionally as a result of injury to the knee joint, pieces of bone or cartilage are chipped off from the articular surfaces, and float about in the knee acting as foreign bodies. They may or may not cause disability, but if they do they should be removed by operation.

In order to reduce a displaced semilunar cartilage which locks the knee joint, that is, prevents full extension of the leg on the thigh, the following procedure as advocated by Jones should be tried. The patient should lie on his back with the knee flexed on the thigh as far as possible, and the thigh flexed on the abdomen. The surgeon then counts three, and then following that, on the word "kick," he extends the leg to its full extension as suddenly as he can. Meanwhile the surgeon holding the leg, rotates the foot inward and pulls, pushing down, with one hand on the thigh. In this way, the distance between the internal condyle and the internal tuberosity of the tibia is increased as much as possible, and by inwardly rotating the tibia, at the time of forcible extension, the cartilage usually can be slipped back into place. Sometimes this method fails even after repeated efforts, and after waiting for a week or ten days for the effusion to disappear, the knee can be operated on and the cartilage removed if necessary.

Prepatellar Bursitis.—Prepatellar bursitis or housemaid's knee is a condition where the prepatellar bursa in front of the knee cap is inflamed, swollen and enlarged, usually as a result of too much kneeling. It is not uncommon in people who scrub floors or others who have to be on their knees a good deal for some reason or other. It appears as a prominent fluctuating swelling directly over the patella, not painful unless acutely inflamed, and it may occur in one knee as well as both. If it is painful and inflamed, and shows signs of containing pus, it should be opened and wiped out with iodin and alcohol, and closed, with the exception of a small wick and a pressure bandage. If not inflamed, the condition can be relieved by simple aspiration with a trocar followed by a compression bandage.

Dupuytren's Contraction.—Dupuytren's contraction is an acquired deformity of the hand, not infrequently seen, in which there is permanent flexion of one or more fingers, usually the third and fourth. It is due to a contracture of the palmar fascia. It is a condition seen much more commonly in men than in women. It may affect one or both hands or any finger, yet it is more commonly seen in the fourth finger than any other. It is supposed to be due to repeated slight injuries to

the palm of the hand, resulting in thickening of the palmar fascia. It appears first as a small lump which can be felt in the palm of the hand near the base of the affected finger. This gradually becomes more marked, and as the condition develops slowly, the finger tip is drawn into the palm of the hand, and the finger is held permanently flexed. This flexion deformity is persistent and permanent, and resists attempts to extension. The only treatment of this condition is operative, and consists of open incision and complete dissection of the palmar fascia with its extension into the fingers.

Synovitis of the Knee Joint.—This most common condition may be due to many causes, but as usually seen is generally the result of trauma, and is known as acute synovitis of the knee, or water on the knee. The treatment is simple, but in spite of that I find that there are nearly as many ways of treating such a condition as there are different physicians. There are definite indications to meet, however, in every case. These are to fix the joint, to prevent weight bearing so as to diminish the pain and tension in the joint, to get rid of the excess synovial fluid, and to restore function within a reasonable time without too great loss of power from muscle atrophy in the leg. Now there are certain definite ways of accomplishing all this.

First, apply a ham splint, or a plaster trough from the ankle to the groin, and have the patient go to bed or keep the leg in a horizontal position. Secondly, apply an ice bag over the knee; fasten this on by a many-tailed bandage, and keep it in position for at least forty-eight hours, when it will be found that the pain has gone and the swelling generally much diminished, meanwhile protecting the skin with a piece of flannel. Many men believe in tapping the knee joint when it is much distended with fluid. The fluid will always go down under the treatment described if given a chance, and I do not believe that tapping should be done except under exceptional conditions, and then with extreme surgical precautions. After the first few days, let the patient get about with crutches without weight bearing, and start baking by electric light, and the use of gentle massage. The massage should never be used directly over the knee joint, but should be applied to the muscles of

the thigh and calf. If the swelling goes down well and the pain stops, do not start passive motion, but take the splint off by the end of the first week, bandage the knee with a flannel bandage, with a felt horseshoe pad about the patella to keep the direct pressure off it, and allow weight bearing, with what use in flexion the patient cares to give the joint. In this way, you can get your patient well more quickly than usual, have a better joint, and a more useful leg than under the old régime, where the splint was put on and left for at least three weeks, at the end of which time the joint, although it might have no fluid in it, was absolutely motionless and stiff, and several weeks more were spent in recovering lost motion and regaining muscle strength. Intelligent use of the joint, even if it has a little fluid in it, does it far more good than all the fixation in the world, and makes for a better and quicker convalescence.

Ganglion.—Ganglion is a common condition usually occurring as a swelling on the dorsum of the hand, but it may occur on the foot or on the flexor tendons of the forearm. It is a small oval fluctuating tumor which causes no pain, and very little inconvenience except from a cosmetic point of view. A common name for this condition is "weeping sinew." It is supposed to be either a hernia of the tendon sheath as a result of injury, or it may be an outgrowth of the synovial fringes of joints occurring in its neighborhood. The sac is filled with a sort of thick synovial fluid, clear and gelatinous in character.

Treatment is either by rupture by force, or by excision by operation. Where the ganglion is small, it can be sometimes ruptured spontaneously by bending the wrist over the back of a person's knee, or the back of a chair, and hitting it hard and suddenly by the back of a heavy book. If this does not suffice, then the only other way to do is to operate on the tumor and remove it by excision. Occasionally after excision of these tumors, they tend to recur.

Tennis Elbow.—This is a condition or disability of the elbow known as tennis elbow, and associated as the name shows with tennis. It is seen not uncommonly following extensive tennis playing, and has been supposed to be due to arthritis of the radio-ulnar joint or to a chronic inflammatory condition of the

supinator longus muscle due to overuse. , Dr. Osgood has shown that it is probably due to an inflammation of a small bursa beneath the supinator longus muscle over the radio-humeral joint. The inflammation of this bursa leads to tenderness over the head of the radius, and to a certain amount of disability, particularly in forced supination. Disability is persistent, and in the past, the treatment has been prolonged immobilization by means of splints or plaster casts with the elbow at a right angle, combined with massage and baking. These methods oftentimes will prove efficient, and establish a cure provided fixation is sufficiently long continued, that is, six or seven weeks. Dr. Osgood has shown in a certain number of cases that dissection and removal of this inflamed bursa has given satisfactory results.

Subdeltoid Bursitis or Peri-Arthritis of the Shoulder.—This is a common disability, and is generally due to inflammation of the bursa underneath the deltoid muscle which may come from arthritis or infection, or from constant overuse due to carrying heavy bundles. The disability is one which results in inability to elevate the arm even up to the shoulder level, and inability to outwardly rotate the arm, so the patient can get the arm behind the head. Sometimes swelling of this bursa can be seen, and oftentimes tenderness can be determined by pressure over the bursa on the point of the shoulder. The condition is not uncommonly called neuritis by most patients. However, it is not a neuritis, and has nothing to do with inflammation of any of the nerves. When it has gone on for any length of time, adhesions form between the walls of the bursa, and x-ray examination may show a certain amount of lime deposit in the bottom of the bursa, or in the tendon of the supraspinatus muscle which lies just underneath the bursa. There may be considerable pain complained of down the arm, particularly on the outer side, and also in the lower arm in the region of the supinator longus muscle.

Treatment is fixation of the shoulder by means of a sling so as to take the weight and drag off the shoulder and arm. The patient should have daily massage, baking and passive and active motion. If the condition does not clear up, or get dis-

tinctly better in a few weeks time, then the arm may have to be manipulated under an anesthetic, and placed in a position of outward rotation, abduction, elevation and supination on a splint, and kept in this position for a few weeks, meanwhile, of course, continuing the daily massage, baking and manipulation. The results in mild cases are good. The results in old, long standing cases are not very satisfactory, that is, there is often a residual stiffness in and about the shoulder joint which does not allow complete normal function.

CHAPTER VII

FLAT FOOT. HALLUX VALGUS. HALLUX RIGIDUS. HAMMER TOE. APOPHYSITIS OF THE OS CALCIS. PAINFUL AND IRRITABLE FEET. MORTON'S TOE. EXOSTOSIS OF THE OS CALCIS

Flat Foot.—The term flat foot is applied to a faulty position of the foot, impairing its weight bearing strength. The normal foot changes its shape as the superimposed weight on the foot is shifted in different directions incident to human activity. Foot strain, weak feet, and pronated feet are all deformities or disabilities caused by a disproportion between the weight to be borne and the muscular power to bear it. Other causes of foot deformities are poor shoes which cramp the foot, faulty position of the feet in standing and walking, injuries which lead to faulty and contracted positions, rickets, foot deformities secondary to infantile paralysis, and club feet.

There are two kinds of flat foot: the flexible flat foot which is a strained or weakened foot with no structural changes, and a rigid flat foot which is a permanent deformity where there are structural changes in the ligaments and bones. In both of these types of feet, the arch instead of being normal in shape is shallow or obliterated.

The foot mechanically is an elastic structure, arched, carrying the body weight and articulating with the bones of the legs through the astragalus. The functions of the foot are weight bearing and propulsion. In the framework of the foot, there are twenty-six bones articulating with each other, and carrying the weight of the body, not only in standing, but in walking. The instep or arch of the foot is convex upward, and the center of this arch is held up or supported by a keystone bone known as the scaphoid. The transverse arch is the anterior arch, so-called, which is limited behind by the cuboid and cuneiform bones, and in front by the heads of the metatarsals. Between the shafts of these metatarsal bones, there is no ligamentous

union, thus permitting marked spreading of the front of the foot in standing or walking. Any compression by shoes which does not allow normal use of the front of the foot in walking or in standing impairs body balance, and results in a tendency to turn the feet out, and to impair the strength of the longitudinal arch.

Compression by tight shoes also restricts the use of the toes, and so decreases the strength of the muscles, and destroys the function of the joints in the toes to such an extent that the front of the foot becomes definitely weakened. The principal muscles of the feet in preventing foot deformities are the tibialis anticus and posticus, both of which run down on the inner side of the foot, one behind the internal malleolus, the other in front, and support the inner side of the foot. Any weakening of these two muscles leads either to pronation of the foot or to flat foot. Improper attitudes have a good deal to do with weakening the foot as well as improper shoeing. Standing with the feet turned out oftentimes tends to roll the foot out or evert the sole so that the muscles and ligaments on the inner side of the foot are strained, and gradually lead not only to foot deformities, but to painful and irritable feet. Shoes should be properly fitted to allow freedom of the forefoot and full use of the toes in standing and walking. Stockings should be big enough so that they do not cramp the toes.

The three common types of feet seen are weak feet, flat feet, and painful and irritable feet. Weak feet are usually seen in children and young people, and in individuals with generally poor musculature, and many others as a result of poor shoes which may cramp the feet and so cause loss of muscle tone. Some feet are no more than pronated slightly, that is, slight eversion of the sole of the foot which brings the weight bearing line inside the inner edge of the foot, and so causes strained, tired feet, and inability to be on the feet long. This condition can usually be relieved by building up the inner edge of the heel about one-eighth or one-quarter of an inch, adding slightly higher shanks to the shoes, or by using felt pads or flat foot plates temporarily. Foot exercises, passive and active, are often advisable, but the result from exercises depends entirely

on the individual's will power to carry them out. At first exercises in painful and irritable feet do more harm than good, and until pain and discomfort have gone, are better omitted. Strapping of the feet by sticking plaster during the painful and irritable stage, and so taking the body weight off the feet and transferring it as much as possible to the calf of the leg, gives a great deal of comfort.

A flat foot is one where the long plantar arch touches the ground in extreme cases, to those where there is only a slight diminution of that arch.

No. 132.—Flat Feet.

No. 133.—Flat Feet from Behind.

These are best treated by temporary splints, such as plates or pads to allow normal restoration of muscle balance combined with foot exercises to strengthen stretched and relaxed muscles. In certain mild cases where the plate does not give relief or seem advisable, a flexible shanked shoe may help by allowing cramped and stretched muscles to do more work and so regain tone. For people who stand a great deal, flexible shanks are not satisfactory, for the foot muscles which do all the work all the time under conditions in which they were never meant to operate, are wholly unsupported. For walking, however, they are good as they allow freer use of the foot muscles than stiff shanked shoes. When the feet are very flat, often plates or shoes are unsatisfactory, and offer no relief, and manipulative or operative

procedures are then in order. On the other hand there are many people with feet which are perfectly flat, who have no symptoms whatsoever, and under these circumstances obviously require no treatment.

Hallux Valgus.—Hallux valgus or bunion is a common deformity of the great toe. The usual explanation of this deformity is that it is caused by too short or narrow shoes, and too small stockings. There is no question but that it is a shoe deformity, and if people did not wear shoes, they would not have bunions. One often hears the explanation that it is a hereditary deformity, but this cannot be accepted. The great toe is turned outward, and the joint at the base of the great toe or the metatarso-phalangeal joint, becomes much enlarged, painful and inflamed. The bursa over this joint, between it and the skin, also becomes much inflamed and swollen, so that walking is considerable of an effort. Associated with bunions one usually finds a broken down anterior arch which is also a source of disability. Associated with the breaking down of the anterior arches, one often finds marked calluses on the bottom of the foot under the heads of the metatarsal bones. Occasionally the deformity is so marked that the great toe will lie directly across, and at a right angle to the other toes.

There are only two methods of treatment for this deformity. One is to wear a shoe which is wide enough with a straight inside edge to prevent pressure on the bunions. The shoe should also be raised on the inner edge so as to tip the foot outward and prevent too much weight bearing on the great toe in walking. A plate or pad can be fitted to the foot as well, in order to prevent too much pressure. If the deformity is slight, an attempt should be made to correct it, not only by the above methods, but also by wearing between the toes a metal or rubber toe post, and at night wearing a small metal splint which tends to adduct the great toe, and keep it in a correct position during the sleeping hours. Manipulation daily of the toe in the direction of adduction may prove useful.

The other method is entirely by operation. The operation is designed to remove a part or whole of the head of the first metatarsal bone, to lengthen the extensor longus hallucis tendon,

No. 134.—X-ray of Case of Hallux Valgus or Bunions.

and place the toe in the same axis as the first metatarsal bone. Following this operation, narrow shoes cannot be worn without a recurrence of the deformity.

No. 135.—X-ray of Case of Hallux Rigidus. Note new bone formation about the metatarso-phalangeal joint of big toe.

Hallux Rigidus.—Hallux rigidus is another condition of the big toe joint which causes a good deal of pain and discomfort, and results in a stiff metatarsophalangeal joint. It is caused by hypertrophy or over-growth of the bone on the distal end of the first metatarsal, and any excess overgrowth of this bone not only tends to lessen motion in the big toe joint, but causes discomfort from pressure made by the shoe, which pressure may

rub the skin off the foot at this point. Occasionally this condition is seen in both feet, but is more common in one.

The treatment of this condition is freedom from shoe pressure at this point, supplemented by a long, stiff shank running out to the end of the shoe so as to prevent, as much as possible, motion of this joint in walking. Freedom from motion in this joint, as well as freedom from pressure of the shoe, usually relieves the symptoms. Where the overgrowth of bone has been excessive, and pain persists in spite of palliative treatment, the bony ridge may have to be operated on and chiselled away. It is a condition which is not uncommonly associated with arthritis.

Hammer Toe.—Hammer toe is a claw-like contraction in flexion of one of the toes, usually the second or third. The contraction takes place at the middle joint of the toe so that in walking or in weight bearing with the foot on the ground, the end of the toe sticks directly down on to the ground. Over the projecting joint which is flexed, there is very apt to be a tender callus. The cause of this deformity is not particularly well understood, but is supposed to be due to poor shoeing.

The treatment in slight cases before much contraction has developed may be directed towards preventing further flexion deformity of the toe. This can be done by means of an insole to which is attached an elastic band which goes over the toe inside or outside the stocking, and prevents it from flexing. If it goes on outside the stocking, the stocking has to be made like a glove so that the elastic band can be applied between the toes. If this method is not successful, a light tin or aluminum splint with the toe strapped to it should be tried. If the condition is bad, a resection of the joint at its point of flexion has to be performed, which tends to relieve the deformity but leaves the toe a bit shorter than the others.

Apophysitis of the Os Calcis.—There is a painful condition of the heel often called to one's attention, which always occurs in children, generally those who are overweight for their years, are physically active, and have strong muscles.

The picture is somewhat as follows: the child is usually seen on account of a slight persistent limp, with a marked disinclina-

tion to complete the full step in walking. There is also tenderness complained of about the posterior aspect of the heel, low down, which has persisted for several weeks or months without change. The child has usually worn a low shoe or sandal, with either a spring heel or none. There may or may not be a history of injury, but the child is generally well overweight for its years, has been very active, and is strong physically. There also may be a slight amount of pronation of the foot. That the condition may also be secondary to undue shoe pressure on the heel from a tight or too close fitting counter I believe has not been determined.

An examination shows a moderately tender area on pressure over the posterior portion of the os calcis, deeply situated, and localized in front of the tendo-Achillis on either side. There is invariably moderate porky thickening about the whole posterior portion of the os calcis, with some tenderness, and with partial obliteration of the hollows on either side of the tendo-Achillis. The motions of the foot are all slightly limited, especially in full dorsal flexion, and any movement which tends to put a strain on the tendo-Achillis causes pain. There is pain and tenderness on weight bearing when the heel is put on to the floor, but less so when walking on the toes with the heel elevated.

The disease resembles somewhat the condition known as achillobursitis, an inflammation of the bursa between the tendo-Achillis and the os calcis, but is much more extensive and deep seated. There is also to be considered before making a diagnosis the condition of tenosynovitis of the tendo-Achillis, and calcaneal spurs on the under surface of the os calcis. These spurs, however, rarely if ever appear so early in life. Tenosynovitis is easily distinguished by the presence of the tendon crepitus and pain referred to the tendon itself on motion. There is also the condition where the bursa between the tendo-Achillis and the skin of the heel is irritated from shoe pressure, which has to be differentiated.

The x-ray will usually clear up the question at once, but even without this the condition is fairly characteristic. The x-ray findings are of interest, and are practically constant whenever

the ossification of the epiphysis is sufficiently developed to show the characteristic changes. There is always to be seen in comparing the plates of the two feet an enlargement of the epiphysis itself on the affected side, both in thickness in the antero-posterior plane, and also in length from top to bottom. There is also considerable cloudiness along the epiphyseal line between the epiphysis and the os calcis, suggesting a deposit of new bone, and often with a partial obliteration of this epiphyseal line. These findings are typical and constant, and never occur in any other condition. Often the condition suggests a slipping of the epiphysis, with the customary inflammatory reaction following such a condition, or epiphysitis. Similar conditions existing in the tibial tubercle have been spoken of as the Osgood-Schlatter disease.

In differentiating this condition from tuberculosis, it must be remembered that tuberculosis generally attacks the anterior portion of the os calcis, does not lead to bone hypertrophy, and is usually unilateral.

Development of the Epiphysis of the Os Calcis.—The epiphysis of the os calcis may develop by one or two centers. It is stated that the centers of ossification appear in the epiphysis at the ninth year on the average, and that the epiphysis is united to the os calcis either before puberty or soon after. I think that the epiphyseal ossification usually begins well before the ninth year, for in all the cases I have seen the x-ray shows it developed by seven years. When the epiphysis develops by two centers of ossification, care must be taken in interpreting the x-ray not to confuse the condition with that of a fracture of the epiphyseal cartilage, as may well be done.

It must be remembered, however, that children large for their age will always show greater and earlier epiphyseal development than underdeveloped children, or even normal sized children of the same age.

The treatment is usually simple, easily applied, and carried out. There are two indications to be met, namely, to relieve the strain on the tendo-Achillis, and to prevent undue weight bearing on the heel.

For the purpose of relieving the tendo-Achillis, which is

attached in part to the epiphysis, the heel of the shoe is raised one-quarter to one-half an inch, and the stiff counter of the shoe is removed to prevent any pressure on the heel. Strapping the heel with several vertical strips of narrow adhesive plaster, extending around the heel and well up the leg on either side gives great relief and support. This strapping should be done with the foot at a right angle to the leg and applied with tension. If there is much element of pronation present a quarter-inch lift is put on the inner edge of the heel to tip the foot out slightly.

To prevent pounding of the heel in walking, a rubber heel is fitted to the shoe, and a pad of sponge rubber is put inside the heel of the shoe to make a soft elastic pad on which the heel may strike. In connection with these procedures hot and cold douches applied daily, electric light baking, and rest are of great additional help.

The duration of the condition varies greatly. There may be a complete cure in a few weeks, but more often the condition persists for several months, and may recur at a later period of growth before puberty, following overuse or injury under unfavorable circumstances. Ultimately, however, the condition is cured by the fusion of the epiphysis with the os calcis.

Conclusions.—1. Apophysitis of the os calcis is not an unusual condition.

2. It may occur from muscle strain in rapidly growing children.

3. It may occur less frequently from direct trauma, but presents then the same clinical picture.

4. It never occurs after puberty.

5. The treatment is rest and protection.

6. The cure in all cases may be arrived at eventually.

Painful and Irritable Feet.—Feet in this condition are the result of overuse, either in an acutely inflamed state or as a result of longstanding abuse. This abuse results in a very stiff, inflexible foot held in pronation with marked general contraction, spasms, and pain on attempted motion, particularly in adduction and dorsal flexion. Feet of this type are best treated by rest, or if not very bad, by strapping with sticking

plaster, and freedom from weight bearing; or if the condition is bad, by plaster casts extending to the knee, put on with the patient under ether. Under the anesthetic, stretching and manipulation in the direction of adduction should be done with plantar flexion, and then dorsal flexion and inversion. Oftentimes a division of the perineal tendons, occasionally a tenotomy of the tendo-Achillis, are necessary but not always helpful. The feet are then put up in extreme varus, inversion and dorsal flexion, and kept in casts in this position for at least three weeks, and possibly six, depending upon the severity of the original condition. Weight bearing can be carried out as soon after operation as the patient can comfortably walk on the side of the cast. Crutches, of course, have to be used to keep the balance. Following the removal of the casts, the patient should have daily massage, and manipulation of the foot in the direction of correction, with a brace to maintain the position. The shoe should be raised on the inner edge, and possibly a plate instead of a brace will tend to establish a cure. Many of these feet are associated with arthritis of the joints of the feet, as well as other joints of the body, and this foot condition is but a local manifestation of a general condition.

Treatment of Affections of Anterior Arches—Morton's Toe.—There are several methods of combating discomfort due to pain through the anterior arch of the foot. A simple method is that devised by Sir Robert Jones which consists of a bar of leather placed across the foot under the tread, and well behind the heads of the metatarsals. This bar of leather is usually one-quarter inch thick and one-half inch wide, and should be placed just behind the heads of the metatarsal bones so that in walking or standing, the weight does not come on the heads of the metatarsals. If this method does not suffice, a metal plate may be fitted which will, by its convex shape in its anterior portion, brace up the heads of the metatarsals, and so restore the normal arch. This plate requires considerable care in fitting, and considerable adjustment. It is best made from a cast of the foot. In the acute stages, a simple felt pad placed behind the heads of the metatarsals and fastened by means of sticking plaster straps around the foot will oftentimes give relief.

No. 136.—Exostosis of Os Calcis or Policeman's Heel. Note spur on under side of os calcis.

Exostosis of the Os Calcis.—This is a condition of the heel where the patient complains of pain in standing and walking, the pain being referred to the under side of the heel, and generally localized very sharply to a place about the size of a ten-cent piece. Sharp pressure with the fingers at this point usually causes a good deal of discomfort. It is a condition which has been commonly known as "policeman's heel," and as the name suggests, is the result of overuse of the foot in standing or walking, or it may be due to an infection of one type or another, either rheumatic or gonorrheal. The condition is not infrequently seen in cases of gonorrheal arthritis.

The pain from these spurs if not relieved by pads, strapping, or lack of weight bearing for a while, may be relieved by operation which usually gives permanent relief. In certain cases the presence of the gonococcus has been determined at operation. Practically all cases can be cured by adequate support of the foot, by means of plates or pads, and operation is rarely necessary.

There are various methods of relieving pressure; one is to strap the heel with sticking plaster, extending the sticking plaster well up on the leg, covering the heel before applying the sticking plaster with a doughnut-shaped piece of felt, so that the hole comes over the tender area. Supplementing this, a hole may be cut out of the heel of the shoe inside, which allows complete freedom from pressure on the heel, and also a piece of sponge rubber may be cut to fit the heel inside the shoe. Another method is one which utilizes a felt pad, rather thick felt being used, to support the longitudinal arch of the foot so as to take the weight off the heel, and a felt doughnut incorporated in the pad in the heel portion to relieve direct pressure on the bony spur. Practically all of these cases get well by some such method of treatment, and rarely come to operation. It is essential in the cases due to gonorrheal infection that the original source of the disease be cured before much relief is to be expected from the local manifestations in the heel.

CHAPTER VIII

BRADFORD ABDUCTION SPLINT. KNOCK-KNEE IRONS. BOW-LEG IRONS. VALGUS SHOE. CLUB FOOT SHOE. FIXATION SPLINT—ANKLE. PLASTER CASTS. PLASTER BANDAGES. PLASTER SPICA. PLASTER JACKETS. LEATHER JACKETS. CELLULOID JACKETS. THOMAS SPLINT. CALIPER SPLINT. SPLINTS FOR TUBERCULOSIS OF THE SPINE

Bradford Abduction Traction Splint.—This splint is made exactly like the Thomas knee splint excepting that the ring is different, and a ratchet and windlass similar to that of the traction hip splint is put in the foot piece. This offers no difficulty if the foot piece be forged out of the uprights or welded on to them. For a child of ten, it is made of soft steel, five-eighths inch wide, and one-quarter to three-eighths inch in thickness. At the upper end of the splint instead of the ring, a wire follows the same shape as a wire ring would, leaving the anterior fifth out, but, over the spine of the pubis, the wire curves sharply upward and inward across the median line of the body to a corresponding point on the opposite side, where it curves downward, backward, slightly inward, and finally slightly backward and outward to cover the tuber ischii of the opposite side. The entire ring must be fitted on the child to allow room for as much space as is used on the ring of a Thomas knee splint, the only difference being that the whole of the wire is covered with felt and leather. These horns act as a crutch-like pad to press against both ischii, and act as a perineal crutch for both sides. The wire top is secured to the uprights by brazing as in the Thomas splint. A two-inch strap is sewed across the upright behind the knee, and a leather strap attached to the outer upright passes over the thigh under the inner upright and back over itself to buckle. This strap is at least two and a half inches wide. A narrow leather strap and buckle attached to the outer upright serves to hold the ankle steady in the splint. In fitting the splint to the child, the two perineal crutches should be so adjusted by bending that when the exten-

sion is tightened, the thigh is abducted about 20 degrees. The bottom of the splint extends about two inches below the sole of the boot. A two-inch high sole on the well foot and crutches should be used.

Knock-knee irons are used for the correction of knock-knees during the soft boned period of early growth. With rare exceptions this age is limited to four and one-half years. They may also be used to prevent the return of deformity after discarding plaster of Paris bandages after an operation.

The brace consists of (a) an upright; (b) a base piece attached to the sole of the boot; (c) a leather belt for waist and leather knee pad straps. As these splints are always made for little children they must be light.

(a) The upright is a strip of tempered steel one-half inch wide, and one-sixteenth inch thick, rising vertically from a point opposite the ankle joint to the trochanter major where it bends at an angle of 45 degrees upward and backward to terminate in a belt just below the posterior superior spine of the ilium. The bottom of the upright is perforated for a quarter inch rivet which fits loosely to make the ankle joint. This upright does not conform to the line of the outer side of the leg but is straight and rigid.

(b) The base piece takes a right-angled bend which divides it into an upright portion and a sole portion. The part for the sole is a triangle with equal sides, a little less wide than the boot heel and terminating in front in a broad rounded point.

The vertical portion becomes of the same size as the upright, and is perforated opposite the ankle by a hole large enough for the quarter-inch ankle pin to play in freely. The latter is riveted so as to secure the upright and foot piece loosely and allow of motion. The vertical portion of the base piece must project away from the outer border of the boot so that the ankle bone may not strike it. At the bend over the top of the upright is placed a large round thin steel pressure pad.

(c) The belt is a strap from the tip of the upright to the point where it bends. At the knee, two pairs of buckles, each pointing forward and backward are riveted to the upright about the middle of the thigh and calf to receive the straps

from the leather pad; the latter, consisting of a rectangle of soft leather as long as the space between the buckles and as wide as half the circumference of the leg, is secured by two straps in front of the leg and two behind. These straps when tightened draw the knee toward the upright and prevent flexion of the knee.

Such a splint is made from the following measurements: a tracing of the entire limb from the waist to the foot and up to the perineum, inclusive, the distance from the sole to the ankle joint, from the sole to the bend of the upright (trochanter); also, the waist measure, the thigh, knee, and calf circumferences, and the patient's boot.

Bow-leg irons are used for the ambulatory treatment of lateral bow legs in the early childhood; they are valueless after the child reaches four and one-half or five years. The soft infantile condition of the long bones may be recognized by bending the lower leg slightly between the hands to see whether it springs or is rigid. They may also be used after operations for correction of deformity at the time when plaster of Paris bandages are discarded, but only to prevent recurrence.

The splint consists of a base piece and upright. The base piece is similar to that of the knock-knee iron, only the vertical part rises at the inner, instead of the outer side of the boot. It is firmly fastened to the sole and under the heel of the boot.

The upright extends from the ankle to a finger's breadth below the perineum where it bends at an angle of 45 degrees upward and outward to encircle the anterior half of the thigh just below the fold of the groin. The size and weight of the upright is the same as for the knock-knee iron, one-half inch wide and one-sixteenth inch thick. A large round pad of thin steel is riveted to the place where the upright changes its direction at the upper end.

The curved upper part of the upright is covered with leather. A strap from the point of the bend passes behind the thigh to buckle at the end of the upright. Three or four pairs of buckles facing front and back are riveted to the upright, two inches apart, opposite the greatest bowing of the leg, to receive the straps of a leather pad similar to the one for knock-knee, which

of course is applied against the outer side of the leg instead of the inner side of the knee.

The valgus shoe is used chiefly for paralytic valgus, and temporarily for resistant flat foot after operation; occasionally for bad results from Pott's fracture.

The apparatus consists of (a) the sole plate; (b) the angle iron; (c) the upright.

(a) The sole plate is cut from sheet steel one-twenty-fifth to one-twentieth of an inch thick by a pattern of stiff paper fitted to the foot. The pattern is prepared from a square sheet of paper each side as long as the foot, creasing it so that the two halves are at right angles with the crease against the outer border of the foot, one half applied to the sole, the other to the outer side. It is marked in pencil at the base of the little toe, under the great toe, a finger's width below the tubercle of the scaphoid, and in front of the tip of the heel, and the outer side is marked the height of the little toe and of the os calcis. The pattern cut from an outline connecting these points is trimmed to the exact shape required. Under the hollow of the sole, the plate is raised by forging, and this may be shown on the pattern by indicating the height to which it should be raised.

(b) The angle piece of soft steel one-eighth to one-tenth inch thick and seven-eighths inch wide is bent at a right angle, the lower half attached to the sole plate and the other giving attachment to the upright by a movable ankle joint. The upright part is bent out in an offset to avoid pressing on the malleolus.

(c) The upright is of steel one-half inch wide and three-sixteenths inch thick, slightly broadened by forging at the lower end where a quarter-inch hole receives the rivet for the ankle joint. The distance from the sole of the ankle joint determines the position of the rivet for the ankle joint. The upright extends from this point to two fingers' breadth below the head of the fibula. Here the upright bears a posterior half bend of steel an inch wide and one-twentieth inch thick. The calf band is lined with thin leather and secured to the leg by a strap. The sole plate is also leather covered, and there is often added a T strap of leather riveted to the highest point on the sole plate, and cut so that the horizontal arms can be buckled around

the upright and the ankle without interfering with ankle movement. If it is desired to prevent toe-drop or heel walking, suitable stops may be put in the joint of the apparatus.

The shoe is made from the following measurements: (1) a paper pattern of sole plate; (2) height of ankle joint from sole; (3) height of top of splint from sole; (4) circumference of calf at level of top of splint.

The club foot shoe is used for (1) a walking splint for the foot for gradual correction, by walking, of varus or equino-varus club foot; (2) for postoperative retention of an over-corrected position; (3) for paralytic varus and equino-varus deformity, either by gradual correction or holding the foot in a suitable position to walk on.

It consists of (a) sole plate; (b) angle piece; (c) uprights.

(a) The sole plate is cut from sheet steel one-twentieth to one-sixteenth inch thick for a child, by means of a paper pattern made from the foot. It consists of a horizontal part for the sole, and two upright flanges, one to fit against the inner side of the great toe and its metatarsal, the other to the inner side of the os calcis. The paper is folded, marked, cut out and fitted on the patient's foot, making it narrower than the foot so as to allow for lateral compressibility, and to permit a boot to be worn over it.

(b) The angle piece of soft steel serves to connect the sole plate with the upright. It is an inch wide, one-twelfth to one-eighth inch thick according to age, and a right-angled bend divides the horizontal from the vertical part. The horizontal part, riveted to the sole plate, crosses its whole width, and for heavy children extends forward also along the outer border of the sole; the sole plate is riveted to it. The vertical part reaches a half inch above the ankle and takes an offset to avoid the malleolus. A quarter-inch rivet attaches the upright to it, which fits loosely to make an ankle joint, and a pin acts as a stop to prevent toe drop.

(c) The upright extends from the angle to an inch below the head of the tibia. It is three-quarters of an inch wide by one-quarter thick, and is somewhat flattened on the lower inch and

a half where it is joined to the angle piece. It also has a slight offset to avoid the malleolus.

At the top a thin plate of steel cut square is riveted to the upright as a pressure pad, where a broad leather strap and buckle secures it around the calf of the leg. The sole plate is lined with leather and has three webbing straps to secure the foot; the first, starting from the top of the flange on the inner side of the heel, surrounds the ankle, and descends over the astragaloscaphoid joint to buckle to the angle piece; the second, starting from the back of the sole plate, passes forward below the outer malleolus over the cuboid to a second buckle close to the first; the third starts from the middle of the outer edge of the sole plate, fastens to the flange by the great toe and holds the metatarsus to the plate.

The shoe is applied to the sole of the foot, which is then firmly strapped to the sole plate regardless of the position of the upright; then the latter is replaced and strapped to the calf of the leg, throwing the foot into over-correction. The amount of correction is regulated by bending the upright from time to time. It is generally better to have the upright well across the line of the leg when strapping on the sole plate. Then when that is done, the upright as it is brought inward to its position throws the foot out into abduction and eversion.

The shoe is made from the following measurements: paper pattern of sole plate; height of ankle from floor; total height of splint from floor; circumference of calf. State whether or not a stop is needed in the joint, and whether for right or left foot.

In little children, toeing in with the splint on is sometimes troublesome. This can be prevented by prolonging the upright to the waist in the following way: the upright is made to rise from the ankle to the middle of the shin where it crosses the front of the leg to rise again to the knee on the outer side. Here it is jointed to a thigh piece extending to a finger's breadth above the trochanter where it takes a bend on the flat backward and upward at an angle of 30 degrees across the buttock toward the posterior spine of the ilium; a strap from the tip around the waist buckles to the bend; another secures the thigh

above the knee; and a third secures the calf where the upright crosses from the inside to the outside of the limb. Tightening the upper strap tends to turn the foot out.

The fixation splint for the ankle is designed to give fixation to the ankle joint when the plaster bandage is discarded. It is largely used after operations of arthrodesis and tendon transference when at the end of a month, it is desirable to let the patient walk; but at first, weight bearing must be prevented by putting a high sole on the well foot and using crutches; or, wearing the Thomas knee splint in addition to the fixation splint.

The splint consists of (a) a posterior half band fitting the calf; (b) outside and inside uprights made of a single piece bent under the sole; (c) a foot plate with its leather lacing like the upper of a low-cut shoe.

(a) The posterior calf band, one and one-quarter inches wide and one-twentieth inch thick, is long enough to fit exactly the posterior half of the leg at the upper part of the calf. It is lined with leather, and a broad strap and buckle secure it to the leg.

(b) For the uprights a single piece of soft steel five-eighths inch wide and one-eighth inch thick is bent to conform to the tracing of the foot and leg accurately, leaving a little extra space around the malleoli; beneath the sole it is made flat where the sole plate is riveted to it. The upper ends of the uprights are riveted to the calf band.

(c) The foot piece is a plate of sheet steel one-twentieth to one-eighteenth inch thick cut a little narrower than a tracing of the foot, and also to the shape of the inside of the boot; it should extend from the heel to the tips of the toes. It is firmly riveted on top of the horizontal part between the uprights and has riveted to its upper surface a piece of soft leather cut by a pattern like the upper of a laced boot, covering the front of the foot and the ankle and leaving the point of the heel exposed. The front edges form two flaps which almost meet and lace like a boot on the front of the foot and ankle.

If the splint is to be used without weight bearing, it may be somewhat lighter.

Plaster of Paris casts, the best records of many deformities, are also useful at times for fitting apparatus. Excellent molds are made of dental wax, but most good molds are made by shaking plaster into water to form a creamy paste.

For a complete cast of the foot, pour enough of the paste into an empty pan to cover its bottom, one to two inches deep. Immerse the foot, previously greased or powdered with French chalk, so that it does not touch the bottom and can easily be withdrawn after hardening. Let it set. Grease the exposed plaster and pour on freshly prepared plaster paste. Before it becomes quite hard, divide it to the skin with a blunt spatula, from the top to the lower part of the mold, in a vertical line, at the center of the heel, over each malleolus and over the great and little toes. When hard enough, gently pry off the fine upper pieces and release the foot. Coat the inside with a layer of shellac, and cover this with a thin layer of oil or French chalk powder. Fit all the pieces of the mold carefully together and fill with creamy plaster paste. After several hours tap the outside of the mold all over with a stick and gently pry off the mold from the cast. A rough mold may be made more quickly by applying a wet plaster bandage, cutting and removing it as soon as set, and bandaging it empty to retain its shape. When dry, one end is stopped by bandaging on a cover of stout paper and the plaster cream is poured into this receptacle until full. Do not peel the bandage mold off until the cast is very hard and dry. This method is used in fitting an artificial limb to an amputation stump, but the end of the stump is then bandaged in.

When a cast is wanted for making a leather or celluloid jacket, a plaster jacket may be similarly used for a mold, and for convenience in subsequent handling, a steel or wooden spindle may be pushed through it before the cast is poured.

When a cast of the back only is desired for making a steel brace, the powdered back of the prone patient is covered by to and fro turns of wet plaster bandages as for a plaster bed; only a light shell is needed for a mold.

Plaster casts for flat foot plates are made in two ways: Whitman has the sitting patient cross the leg over the knee, and

place the outer side of his foot on wet plaster paste lying on a sheet of cotton wadding on a chair or stool; then by turning the cotton and plaster over the sole and inner side of the foot, and holding it there till set, a cast is made of the foot in as much supination as the patient can have. The other method is to let the patient, sitting, hang his foot in plaster paste which covers as much of the sole and sides of the foot as wanted. In this position the foot is not supinated, therefore, the cast must be carved with a knife to give the proper shape for the plate. This requires a little practice, for one must judge of the amount of soft yielding tissue which slips out of the way of plate pressure and one must apply pressure only where it is needed. A line is drawn on the cast, showing the border of the plate. Steel plates are made of soft, malleable sheet steel, one-twenty-fifth to one-twentieth of an inch thick cut on this outline and hammered into shape while red hot on the cast. They are subsequently tempered and nickel-plated. Aluminum, bronze and other materials like thick celluloid are also used.

For making casts, commercial plaster of Paris is good enough; but for bandages, a purer plaster, or the so-called dental plaster, is necessary. The latter may contain some sulphate of potash to accelerate setting, but it also makes the bandage a little less durable, as does salt added to the water.

Plaster Bandages.—For bandage cloth, use crinoline gauze stiffened with starch, for a glue or dextrine stiffening may delay or prevent setting. The mesh should be about thirty threads to the inch. Tear in strips five yards long and three and four inches wide. (For infants, especially with club feet, have a few as narrow as two inches.) Roll them all loosely; put one on a smooth tray with half a yard unrolled, rub the dry plaster in with the hand, roll it, and treat the next half yard in the same way, and so on, until it is all loosely rolled up, full of dry plaster. Do not roll tightly for they will not then wet quickly when immersed. Keep in wooden or tin boxes.

How applied: the protective layer or lining. This may be thin. Stockinette is enough where there are no marked bony prominences and where no swelling is expected, otherwise, thick, sheet cotton batting or felt pads are needed to prevent pressure

sores. After completing the lining, lay two or three bandages horizontally in a pail of tepid water; when bubbling stops, take one out and squeeze half dry with a hand on each end of the bandage; unwind about a foot, and begin winding on with even pressure round and round, overlapping well and rubbing each turn to incorporate them together. Eight or ten layers are thick enough excepting around the hip and knee. Where extra strength is required, reinforce with more turns or plaster ropes. Work quickly, so that the whole sets at practically the same time. When finished do not add more plaster paste or water, rub smooth with a towel or the hands. Before leaving it to set, it is well to turn over the exposed end of the lining so as to make a soft end to the bandage.

There are three chief faults of plaster bandages: (1) a short bandage fails to immobilize and is, therefore, bad, *e.g.*, you can only fix a knee by a bandage extending from ankle to groin—anything short of that allows some motion. (2) A loose bandage fails to immobilize; apply each turn with a firm even pressure. (3) Uneven bandages are of two sorts: those unduly thin and weak in places, and those which are somewhere too tight. These, by constriction, produce venous stasis, blueness, and swelling of the part projecting beyond the bandage.

A jacket may impede respiration, causing generally cyanosis, pain, sometimes syncope, and vomiting. The same effect may come from a bandage which is uniformly too tight. A faulty bandage should be replaced by a good one, but if this is impracticable, cut the plaster from end to end, spring open a little and bandage it together with a gauze or muslin bandage.

For cutting plaster bandages off, many shears and saws are made, but there is nothing better than a short knife such as leather cutters use. Wet the plaster with water applied with a medicine dropper or ear syringe before cutting.

Plaster Spica.—For fractures, osteotomies and sensitive conditions of the hip joint, a spica should be applied with the patient in the recumbent position: (1) table; (2) small sacral support; (3) support for body and head of the same height as sacral support. The leg should be held by an assistant.

The lining may be thin, cotton batting or stockinette with

pads provided for the anterior superior spines of the iliac crests, the sacrum, knee and malleoli.

When the plaster bandage is half as thick as intended, reinforce around the hip, cover in the whole side, and back of the buttock as well as the groin for strength. When set, trim around the perineum and anus, aiming to insure cleanliness without weakening the plaster.

Plaster Jackets.—1. Sayre's method: suspension: requires a head sling, block and cord for suspension, lining of stockinette or an undershirt, extra protection for anterior superior spine, crests, kyphos, and mammæ.

2. Hammock jackets require a one-inch iron pipe rectangular frame six by two feet, with a simple device to stretch on it a hammock cloth as wide as the distance between the anterior superior spines and longer than the patient, and is so arranged that the cloth can be tightened or slackened during application.

3. The Goldthwait method requires supports for two irons one-half by one-eighth inch, on which the patient lies, like the uprights of a steel back brace. These supports may be made either to stand on a table or to fit a hammock frame. The patient in undershirt lies on his back on the uprights which are bent to give the proper arching and are well padded.

Leather Jackets and Splints.—Jackets of plaster of Paris may be made removable by splitting and sewing on each side of the outer border a strip of leather with lacing hooks, eyelets for lacing, or straps and buckles. They are convenient for cleanliness, but much less efficient than before splitting for they soon crack and weaken in use.

More durable jackets are made of leather or celluloid, or, paper, muslin and glue, molded on a cast made from a plaster jacket.

The leather used is cut from the thicker part of an oak tanned hide, which is thoroughly wet, and one edge is tacked across the median line of the front of the cast; then the rest is wrapped and pulled around the cast so as to conform to it as closely as possible, and the ends are tacked on, overlapping by a good hand's breath. Often there are places where the leather

stretches over the hollow places. Apposition may be secured by winding stout cord or webbing tightly around it, and at times including a felt pad. The smooth side of the leather should be next to the skin. It is a great convenience to have a spindle in the cast during the winding.

The wet leather must now dry; two or three days may be needed, but if left near a stove, twelve to twenty-four hours are enough. When thoroughly dry, it should be untacked and removed from the cast, and trimmed either on the patient or on the cast. This must be done carefully as the ultimate shape of the jacket depends on it; the lower edge should almost reach the symphysis, curving upward and outward just enough to allow sufficient thigh flexion for the sitting attitude. It should come two fingers' breadth below the anterior superior spines, clear the trochanters, and cover the prominence of the sacrum. The upper border may vary a little according to the object desired, usually it should reach to the sternal notch, extend to the coracoid processes, descend vertically to the border of the anterior axillary fold, and either descend enough to come below the low corner of each scapula behind, or rise over the posterior axillary fold to just below the spines of the scapulæ. The anterior margins also require straightening; the outer one should fail to reach the median line by a finger's breadth—the inner should cross about a hand's breadth beyond it so as to prevent pinching the skin, and the leather should be thinned at the edge. Finally, a line is drawn where the lacings are to be fastened.

To finish the jacket, the leather may be stiffened with bayberry wax, the strips of fastenings stitched on, and a coat of shellac applied. Stiffening is done by painting hot bay wax (melted in a shallow pan) until the leather will take up no more. The fastenings are ordinary eyelets or eyelet hooks, such as are used on laced boots, applied near the edge of two leather straps one inch wide, which are then stitched to the jacket along the two lines previously marked. Straps and buckles are better.

The shellac is simply painted on to prevent the leather soaking up perspiration. It is often well to punch out quarter-inch

holes every three inches all over the jacket to allow for its ventilation.

Celluloid Jackets and Splints.—Celluloid jackets and splints may be made in two ways:

1. By heating a sheet of thick celluloid in a tank of boiling water, stretching it around the cast with tongs and quickly modeling it while hot, with the hands protected by thick, woolen mittens.

2. Cover the cast with an undershirt, and paint on many successive coats of celluloid dissolved in acetone. These may be painted on every three or four hours until the required thickness is reached. Some apply a layer of gauze bandage into each coat of celluloid. When finished it must dry for a week before cutting it from the cast; otherwise it curls from unequal shrinkage. These jackets and splints are lighter and cleaner because washable, which leather is not. The trimming, perforating and finishing is practically the same. Both may be reinforced with strips of steel or incorporated as parts of metal splints. The sharp edges should have a binding of chamois leather or sheepskin stitched on.

Glue and paper jackets and splints may be made on any cast covered with stockinette by laying in alternate layers strips of bandage cloth dipped in glue and strips of blotting paper soaked in glue or shellac. When completed, these splints are quite rigid. Leather bindings and strips of fastenings may be glued on and the whole given two coats of shellac.

Leather splints for the arms and legs may be made in the same way. All these appliances of stiffened leather are susceptible of a certain slight amount of remodeling; if an edge sticks in anywhere, it may be slashed, *i.e.*, a series of little cuts may be made a quarter of an inch apart and then rubbed with the handle of the knife until a sort of soft fringe is made; or, if the jacket bears too hard on a bony prominence a small spot may be softened by heating with a candle flame, and remodeled with a stick, holding it till it becomes cool and hard again.

Leather jackets instead of being hardened with wax are better and more comfortable if reinforced with thin strips of steel, sewed on after being carefully fitted to the leather on the cast

This arrangement gives a better and lighter jacket, and is much less harsh to wear.

The Thomas knee splint is a single perineal crutch. It consists of (a) a wire ring brazed to (b) lateral uprights joined together at (c) by a foot piece. The ring is a loose fit around the top of the thigh at the angle of the groin. It is made of No. 5 wire gauge (three-sixteenths inch) which is brazed together and fitted to a pattern giving the required curve. The ring is not round; starting a finger's breadth above the trochanter it curves slightly forward, downward and inward to the adductor tendons, then sharply backward to the tuber ischii from which point it curves gently upward, outward and forward to meet its point of origin. The measurement for this ring is made with a tape measure and follows the line on the skin where the ring is to be. The wire for the ring should exceed the length of this measure by one inch for a small child and two inches for an adult, in order to allow for padding. The uprights are brazed on at the proper spot giving the ring an inclination of about 45 degrees with the horizon. The padding, thin on the outer part of the ring, and thick below, is of felt tightly wound about the ring and covered with soft leather stitched on wet, the stitches being on the inferior surface of the pad along that part of the ring which bears no weight. It should be from five-eighths inch thick for a very small child to one inch for an adult, getting thinner until nearer the outer upright where it is scarcely three-eighths inch in thickness. The two uprights are shaped to the outline of the leg traced on paper. The measurement should be from the perineum to a hand's breadth below the soles; this gives the length for the internal upright; the external one may be computed. Either the two uprights may be made of a single piece of wire bent under the foot, or they may be brazed into the foot piece.

The foot piece may be of various shapes, a very useful one being a round washer, two to two and one-half inches in diameter in which the ends of the uprights are brazed. To give added strength, a short rod, the same size as the upright, is brazed across between them three-quarters inch above the foot piece. The sizes of the uprights for children vary according to

weight, from three-sixteenths inch to one-quarter inch or a little larger for heavy ones. After the ring is padded and the splint tried on, paper patterns are cut and marked for the leather lacings for the thigh and calf. If a plaster bandage is to be worn, no leather knee cap is needed, otherwise, a square of soft leather is fitted each side, being twice the greatest diameter of the patella and fitted with a leather strap and buckle at each corner to strap it to the uprights and keep the knee from bending. The leather should have a hole over the patella to avoid pressure. When dealing with a knee which hyperextends naturally, a three-inch strap should be sewed across between the uprights behind the popliteal space.

The uses of the **caliper splint** are (1) to keep the knee stiff in walking; (2) it may be modified to prevent either toe drop or walking on the heel; (3) it may fix both joints, or it may fix the knee and allow only slight motion at the ankle.

It consists of (a) posterior thigh band; (b) two uprights; (c) socket for heel of boot; (d) leather knee cap.

(a) The posterior thigh band is made to fit the posterior half of the thigh just below the gluteal fold. It is made of sheet steel one-twentieth inch thick, and two to three inches broad. At the lateral margins the outer and inner uprights are riveted. It is lined with leather and a strap and buckle secures the thigh to it.

(b) The uprights, of steel wire three-sixteenths to five-sixteenths inch in diameter, are curved to the outline of a tracing of the leg. The length of the inside upright is from a finger's breadth below the tuber ischii to the sole in front of the boot heel, plus one inch to turn in. This lowest inch is sharply bent inward to slip into the tubular socket in the boot heel.

(c) The socket consists of a steel tube large enough to receive the ends of the uprights and as long as the boot heel is wide. It is brazed to a small plate serving to rivet it to the sole of the boot. The heel is removed and the socket secured so that the tube replaces the front part of the boot heel. The lifts of leather are then shortened in front and reapplied until the level of the top of the tube is reached, when a longer lift of leather covers the heel and tube entirely and is pegged down

in front to the shank of the sole so as to enclose the tube completely.

(d) The leather knee cap is a square of soft leather each side about three times the diameter of the patella with a narrow leather strap and buckle at each corner to attach it to the uprights. There should be a hole for the patella.

The measures for making the splint include an outline of the whole limb, the length of the internal upright, the width between the malleoli, the circumference of the thigh, knee and calf, and the child's boot.

2. When used solely to prevent walking on the heel, or toe drop, the splint may be made so that the uprights fasten in a socket in the heel, modified by making the plate in the heel extend on each side an inch beyond the upright, and turn up as a small flange or stop which strikes against the uprights.

If the stops strike on the back of the uprights, they prevent toe drop; if in front, walking on the heel.

3. By using the longer uprights and the stops, both knee and ankle may be prevented from flexing; and by turning up a double stop, one which will strike the upright in front and another behind, ankle motion is restricted to a few degrees.

This splint is used mostly for paralytics.

Splints.—The back brace for Pott's disease or a modified Taylor brace consists of (a) two uprights; (b) one base or U piece; (c) two shoulder pieces; (d) a cross piece; (e) an apron and straps.

(a) The uprights lie next to the skin over the transverse processes of the vertebræ from the middle of the sacrum to the level of the spines of the scapulæ. For a child, they are of malleable steel, one-eighth to one-tenth inch thick by one-half inch wide, carefully fitted and made rigid by tempering. The required length is measured, the curved shape obtained from a tracing of the back over the spinous processes, made by molding a flexible lead strip to the back of the child lying prone on a flat surface and outlining this curve on paper. Where the kyphos is large and slopes sharply to right and left or unequally, it is better to make a plaster cast of the back, and mark the places

for the uprights, and then fit the uprights to the cast, and later the back itself.

The distance between the uprights must be determined for each child by measurement. There must be enough space between for the row of spinous processes, and yet they must be close enough to lie within the posterior superior spines of the ilia, and avoid pressing on them. Pad plates are attached at the kyphos; they are one-half inch wider than the upright and as long as the kyphos, and are made of thin sheet steel (one-fiftieth inch thick).

(b) The base or U piece is cut from sheet steel one-tenth inch thick, and is either shaped like an inverted U, or is a half waist band. The horizontal limb of the U is above the posterior spines and crests of the ilia, the descending limbs spreading slightly, and points half way between the tuber ischii and trochanters. The tip of each limb bears a round pressure pad of thin steel called a dollar pad. The base is attached by rivets to the uprights.

(c) The shoulder pieces are cut from the same sheet steel by a paper pattern made on the child; the vertical part, a little over an inch in length, secures it to the top of the upright by two rivets; the sloping part runs outward, upward, and forward to grasp the root of the neck, stopping before reaching the clavicle. Shoulder pieces are fitted by bending with a wrench after the brace is completely finished.

(d) Cross pieces are straight bars one-half inch wide by one-twelfth inch thick, ending at the posterior axillary line. They provide a side attachment for apron straps so as to allow more freedom to the thoracic breathing movements. They should be attached just below the apex of the kyphos.

(e) The apron, a double thickness of stout cotton sheeting, reaches from the symphysis to the middle of the sternum, and from one mid-axillary line to the other. It is cut away from the axillæ and groins, and it has webbing straps sewed on near the margins opposite the buckles on the brace. It is often necessary to fit the apron by making gores in the sides. Light steels should be sewed on to it to prevent its crumpling.

THE SPRING STEEL BRACE for use during convalescence

from Pott's disease is designed for the end of brace treatment when muscular spasm has disappeared, and it is only desirable to give a little restraint, and to protect the child in case of a fall. It may also be used for round shoulders. It consists of (a) base, (b) two uprights, (c) a cross piece.

(a) The base is a half band crossing the sacrum below the posterior spines and extending horizontally to end a finger's breadth above the trochanters just behind and below the anterior superior spines of the ilia. It appears straight when fitted, but it must be cut on a gentle curve, and this is best obtained by cutting a paper pattern to fit the patient. The metal should be at least one-twentieth inch thick and tempered rigid.

(b) The uprights extend from the base straight to the level of the seventh cervical vertebra where they bend outward and upward at an angle of 45 degrees to form shoulder pieces two to three inches long. They are made of thinner spring steel one-twentieth to one-twenty-fifth inch thick and are one-half to five-eighths inch wide. They are bent to conform in a general way to the contour of the back, but the lumbar curve is exaggerated to make it springy.

(c) A half-inch-wide cross piece is riveted to the uprights a hand's breadth below the axilla, and serves to buckle the straps from the tips of the shoulder pieces. A broad waist belt four to five inches wide steadies it at the waist, and an inch and a half wide strap secures the pelvis by buckling into each end of the base piece.

HEAD SUPPORTS are of two kinds, those used with back braces, and those used by themselves.

For use with the modified Taylor brace we have the oval ring support consisting of: (a) the brace socket; (b) the adjustable spindle; (c) the oval ring with chin piece and occipital pad.

(a) The socket serves for attachment of the uprights. It is a piece of machine steel, flat in front where it is made wide enough to cover the two uprights and the space between them. Behind, it is flat over the uprights where it is only one-eighth inch thick, but it is five-eighths to three-quarters of an inch thick over the space between the uprights, where it is rounded

from side to side to prevent catching on the clothing. Its height is three-quarters of an inch, and it is pierced by rivet holes to attach it to the uprights, by a large vertical hole for the spindle and behind in the median line by two screw holes for set screws to adjust the height of the spindle. The hole for the spindle conforms to its shape, flat in front and half rounded behind, and it is one-half inch broad by one-quarter inch antero-posteriorly.

(b) The spindle is made both by forging and by turning on a lathe a soft steel bar. Its length varies considerably, but it is usually between four and five inches. The lower two or three inches are forged and filed to the half round shape to slip in the hole on the brace socket. The top for the first half-inch is turned to one-quarter-inch diameter with a slight taper toward the tip. Next there is a shoulder one-eighth inch wider, and below this, it is again narrowed by turning to one-quarter inch, and remains cylindrical till it expands into the lower part shaped for the brace socket, and here a row of slight depressions are made in the median line a quarter of an inch apart for the tips of the two set screws.

The spindle is, therefore, firmly supported, and can be raised, lowered, and removed for sleeping. The narrow part can be bent to conform to the shape of the neck, and to give the proper inclination to the head support.

(c) The oval ring or head support proper is made of two halves hinged together at the right side and arranged to fasten together on the left. The spindle socket supports the posterior half of the ring; the anterior half bears a hard rubber plate fitting under the chin. Both halves of the ring are made of steel three-eighths inch wide by one-eighth inch thick which at one end is sharply thickened by forging out to make the hinge, done by cutting, filing and drilling in the usual manner. The oval shape is obtained from a piece of cardboard cut out and fitted to the proper place on the child's back and head. To the center of the posterior half is riveted the spindle socket, made of machine steel, three-eighths inch wide, two and one-half inches long, one-eighth inch through, except for the central half-inch which is three-eighths thick where it is rounded from

side to side, and has a vertical hole for the spindle to slip in as far as its shoulder.

The front half is a little longer than the posterior one, is similarly curved, and under the chin bears a small half moon of tin soldered on, to which the hard rubber plate is fastened by two small copper rivets. The fastening is made by two fixed pins springing into holes in the posterior half, where they overlap. The ends of the two halves are kept from springing open by sliding a wire ring over the overlapped parts after the pins are in place.

The inner surface of the ring, posteriorly, has riveted to it a half-moon-shaped piece of jacket leather four to five inches long projecting its curved edge upward and backward for the occiput to rest upon.

N.B. To measure for head support, it is first necessary to find where to place the brace socket, in order that the spindle may be vertical, and the socket clear the skin over the spinous processes. The distance from the lower border of the socket to the occipital protuberance and one inch more gives the length of the spindle. For the ring, it is best to cut out of stiff paper a pattern with the paper shaped hole to fit the neck, the occiput and the under side of the chin. The antero-posterior diameter should equal the distance between the mental and occipital processes, and the width exceed the distance between the mastoids by a half inch.

Goldthwait's head support for cervical Pott's disease, to be worn without a brace, consists of (a) the yoke; (b) the wire chin rest; (c) the posterior neck piece with its upright and pad.

(a) The yoke is a strip of soft steel five-eighths inch wide, one-twelfth inch thick crossing the upper part of the sternum, rising to encircle the root of the neck, passing backward and downward to end at the second dorsal spine about two inches each side of the median line. It may be forged to the shape of a paper pattern, but it is better to shape on the child a strip of lead to the form of the yoke and to trace on paper its curves, first laying it on the side, then front down on the paper, and finally to flatten it out on a large piece of paper and cut the yoke pattern from it, trying it on to see if it will do. The yoke

may then be cut from a large sheet of steel and curved to fit the front and the side tracing. It must fit the soft parts accurately and avoid pressing on the clavicles, the spines of the scapulæ, and the sternum. It must fit the child accurately.

(b) Chin rest. This is made of No. 3 gauge (one-eighth inch in diameter) wire from under the chin and the jaw to a point a finger's breadth outside and below the tips of the mastoids, where it takes a sharp right-angled bend downward and slightly outward to the yoke; here it is flattened out, bent sharply forward and curved to fit on top of the yoke.

It is easiest to fashion this out of thinner (No. 14) wire and carefully to copy the model. The part under the chin has a piece of tin soldered to it to which the hard rubber pad for the chin to rest on is riveted, as in the oval ring head support. Three quarters of an inch below the tip of the vertical part a small shoulder is made with solder.

The yoke and chin rest should be tried on unfinished and the place marked where they are to be soldered together.

(c) The posterior neck band, of tempered steel, one-half inch wide, and one-sixteenth inch thick is hinged to the right wire upright just above the shoulder of solder, by bending the end around the wire. It curves gently behind the neck to reach the corresponding part of the left wire upright which it clasps in a hook-like bend, retaining the position by its own springiness.

From its center behind springs a short vertical upright of No. 8 wire, bearing a round pad of hard rubber for the support of the occiput. There is a strap and buckle between the tips of the yoke, from these points a strap and buckle around the waist, and from the lower angles of the scapulæ straps to buckle on the front of the yoke.

It is applied by unclasping and opening the posterior back band, pushing the ends of the yoke back on each side of the neck, till it falls into place; then the neckband is clasped and the straps buckled.

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